THE QUARTZ MERCURY VAPOUR LAMP — FERGUSON

LEWIS
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Sept. 1927.

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ITS POSSIBILITIES AND USES IN PUBLIC HEALTH AND GENERAL PRACTICE

BY

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WITH AN INTRODUCTION BY

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MEDICAL SUPERINTENDENT, LORD MAYOR TRELOAR CRIPPLES' HOSPITALS, ETC.

WITH 38 ILLUSTRATIONS IN THIRTEEN PLATES
AND IN THE TEXT

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INTRODUCTION

BY SIR HENRY GAUVAIN, M.D., M.CHIR. (CANTAB.).

THE quartz mercury vapour is the most generally suitable lamp for employment in private practice or in small clinics.

It is easy to use, effective, rapid in its action, rich in ultra-violet light of therapeutic value, clean, economical both in first cost and current consumption, suitable for either a general light bath or local treatment. It occupies little space, and is easily installed in a doctor's consulting room.

It is, therefore, not to be wondered at that it has achieved great popularity, and has been very generally advocated and adopted.

It may be used to advantage in a large number of pathological conditions, during convalescence from various diseases, or even as a tonic for the weakly and debilitated, but not otherwise sick person.

Its very simplicity is, however, not altogether without drawbacks and dangers, as many have been tempted to use it without sufficient knowledge, and at times with disastrous results. The busy practitioner can hardly be expected to search the literature for information on the technique to be followed, the indications for its employment, its dangers and limitations.

Dr. Ferguson will have rightly earned the gratitude of many by writing this lucid, concise, and admirable little book, which, eminently practical and sound, will give the novice just that essential information and help so urgently needed by those who would add actinotherapy to other means of aiding their patients. It does not pretend to be exhaustive, and is not overburdened with unnecessary details; but this does not detract from its value, rather it

adds to its utility and helpfulness. It would be to the advantage of all concerned if every practitioner possessing a mercury vapour lamp, or contemplating installing one, studied this book carefully. Ultra-violet light treatment has come to stay, and a volume such as this is long overdue and is doubly welcome now that it has arrived. I commend it warmly to all interested in the practical application of ultra-violet light treatment by means of the mercury vapour lamp.

ALTON, HANTS,
July 20, 1926.

PREFACE

ELDERLY medical men, when addressing their local medical societies, are fond of taking as their title "Nova et Vetera," and holding forth at length on the fashions and principles of long ago, to the disparagement of most things new. It is said that there is nothing new under the sun, and, indeed, this is most particularly true of sunlight therapy. It must be admitted, however, that of recent date there has been an extraordinary awakening of interest in the use of light in the treatment of disease, both on the part of the general public and the medical profession.

An astounding variety and number of sources of "artificial sunlight" have been evolved and are now available. At this stage the busy general practitioner finds himself somewhat bewildered. Somehow he appears to be shy about taking up the new form of treatment, and yet he knows that his patients have heard of its existence and are talking about it. Several good treatises on the subject of Ultra-Violet Radiation have been published, but the busy practitioner is left rather at a loss as to what type of apparatus he should purchase, and what exactly he is venturing in the care, cost, and management of such apparatus.

The writer feels that for the man in general practice and for the busy medical officer of health the Quartz Mercury Vapour Lamp is the only practical proposition. He has attempted in this small book to guide the practitioner in his initial steps in practical Ultra-Violet Therapy.

Those who are hesitating are advised to peruse Chapter VII. of this book first. There will be found the type of lamp to buy, a choice of stands and fittings, details of installation, cost of running, notes on care and upkeep of the lamp, and practical hints for the novice as to dosage.

Even the busy doctor with a large panel will find this

form of treatment of inestimable value in his practice, and one which is not included in the scope of contract medical service.

Acknowledgments are due to the British Empire Exhibition Committee of the Royal Society; the British Hanovia Quartz Lamp Company, Ltd.; Messrs. Kelvin, Bottomley and Baird, Ltd.; Mr. F. E. Lamplough, M.A.; and the Sterling Corporation, Ltd., for the loan of blocks illustrating types of apparatus, spectrographs, etc.

I am indebted to Mr. A. A. King, of Langley, Birmingham, for his kindness in reading the proofs; and to Mr. G. H. Roe, of the Smethwick Health Department, for his help in the preparation of the MS. of this book.

J. BELL FERGUSON.

PUBLIC HEALTH DEPARTMENT,
SMETHWICK.

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CHAPTER I

ULTRA-VIOLET RADIATION

Historical

From the earliest periods of the world's history light must have played a dominant part in the production and evolution of the various types of life, both in plants and animals.

It opens up a fascinating vista of speculation to compare the types of men and the types of vegetation in the world to-day in different regions of the earth's surface with the amount of available ultra-violet radiation from the solar spectrum. Without stressing the point, it would seem that the hardier types of both plant and man are evolved where ultra-violet radiation is not necessarily so powerful as elsewhere, but where heat and moisture are curtailed.

It would appear that light has been found absolutely essential to life in evolution. No life can exist in utter darkness.

The beneficial effects of sunlight have been recognised from the earliest times when Hippocrates and Celsus recommended sun-baths. The evolution of modern ideas on radiation goes back to the time of Isaac Newton, who in 1666 discovered the spectrum of visible light. In 1777 Scheele found that silver chloride was darkened by invisible rays above the violet end of Newton's spectrum. In 1800 Sir William Herschel showed that the maximum heating effect in the spectrum was to be found in the region below the red end. In 1840 Herschel proved that the spectrum *did* extend

below this region, and showed that the Fraunhofer lines also extended to this infra-red region. In 1803 Inglefield commented on Scheele's original observations, and suggested that an extension might exist at the violet end of the spectrum similar to that in the infra-red. Ritter and Wollaston were, however, the first to actually demonstrate that photographic plates were readily darkened by radiations above the violet end of the visible spectrum.

In 1842 Becquerel photographed a long ultra-violet region which contained many Fraunhofer lines, and he extended the spectrum to about 3,400 Ångström units.

Light was used quite empirically in the treatment of disease till the time of Charcot, who in 1859 showed that light rays produced an effect on the skin which was quite independent of their heating properties. Only comparatively recently has an idea of the action of light and the precise rays of the spectrum involved in its therapeutic effects been arrived at and elucidated.

In 1893 Professor Finsen, of Copenhagen, showed that it was possible to lessen the amount of scarring in smallpox patients by the use of red curtains, red glass, etc., which excluded the actinic rays of the sun. He demonstrated that sunburn was a reaction of the skin to the actinic rays in sunlight, and that these actinic rays belonged to the ultra-violet region of the spectrum; that they had very little penetrative power in the skin, and penetration of vascular tissue was very small indeed. In 1894 his name became world famous owing to his work on lupus.

Finsen, owing to climatic conditions, relied chiefly on carbon-arc lamps, and was the originator of modern light therapy. Dr. Rollier, of Berne, realised the possibilities of light therapy, and in 1903 started his first light clinic at the Swiss village of Leysin. Rollier confined himself at first to the use of the sun's rays, and his development of "helio-therapy" and his success in certain forms of tuberculosis are now known throughout the world.

Sir Henry Gauvain, at Hayling Island and Alton, has combined the work of Finsen and Rollier, and utilises successfully both natural and artificial sources of light. He

realised that atmospheric conditions in this climate were not comparable to those of a Swiss village some 4,700 feet above sea-level. A Finsen Light Clinic was established at the London Hospital under Dr. Sequeira some twenty years ago, but light treatment was overshadowed by the discovery of Roentgen rays about 1895, and never became widely used in this country.

Ultra-violet radiations have been suspected or known for nearly a century and a half, but it has remained for the twentieth century to usher in their practical application on a wide scale in the cure or alleviation of disease.

CHAPTER II

PHYSICAL, CHEMICAL, AND PHYSIOLOGICAL PROPERTIES OF ULTRA-VIOLET RADIATIONS

I. Physics of Ultra-Violet Radiation

Modern theories regard radiation as a propagation of energy in the form of waves. These waves have been shown to vary continuously in length from 20,000 to 30,000 metres in the wireless region to the extremely short vibrations involved in radium emanations.

A purely arbitrary unit of measurement has been adopted for measuring and calculating the wave-lengths of visible and invisible light. This is known as the "Ångström Unit," which is one ten-millionth of a millimetre, and is abbreviated as Å. The visible spectrum, as will be seen from the accompanying diagram, covers a very short range of these waves—from 7,600 to 3,900 Å.

Photographic methods are conveniently used in investigating the ultra-violet regions, and great technical difficulties have been overcome in this field of work.

Glass absorbs wave-lengths shorter than 3,300 Å., and so lenses and prisms of fused quartz are used. With these, wave-lengths of 1,850 Å. have been reached. For regions with wave-lengths shorter than 1,850 Å., fluorite lenses, high vacua, and specially prepared photographic plates with very thin "gelatin" are used. Schumann, by improving the photographic plate, investigated the far end of the ultra-violet spectrum, which is now often referred to as the "Schumann Region."

There remained a band of short wave-lengths between 1,000 Å. and the long (soft) X rays.

Lyman, by dispensing with fluorite prisms and using a ruled grating, got down to 1,030 Å. Millikan got down to 150 Å.

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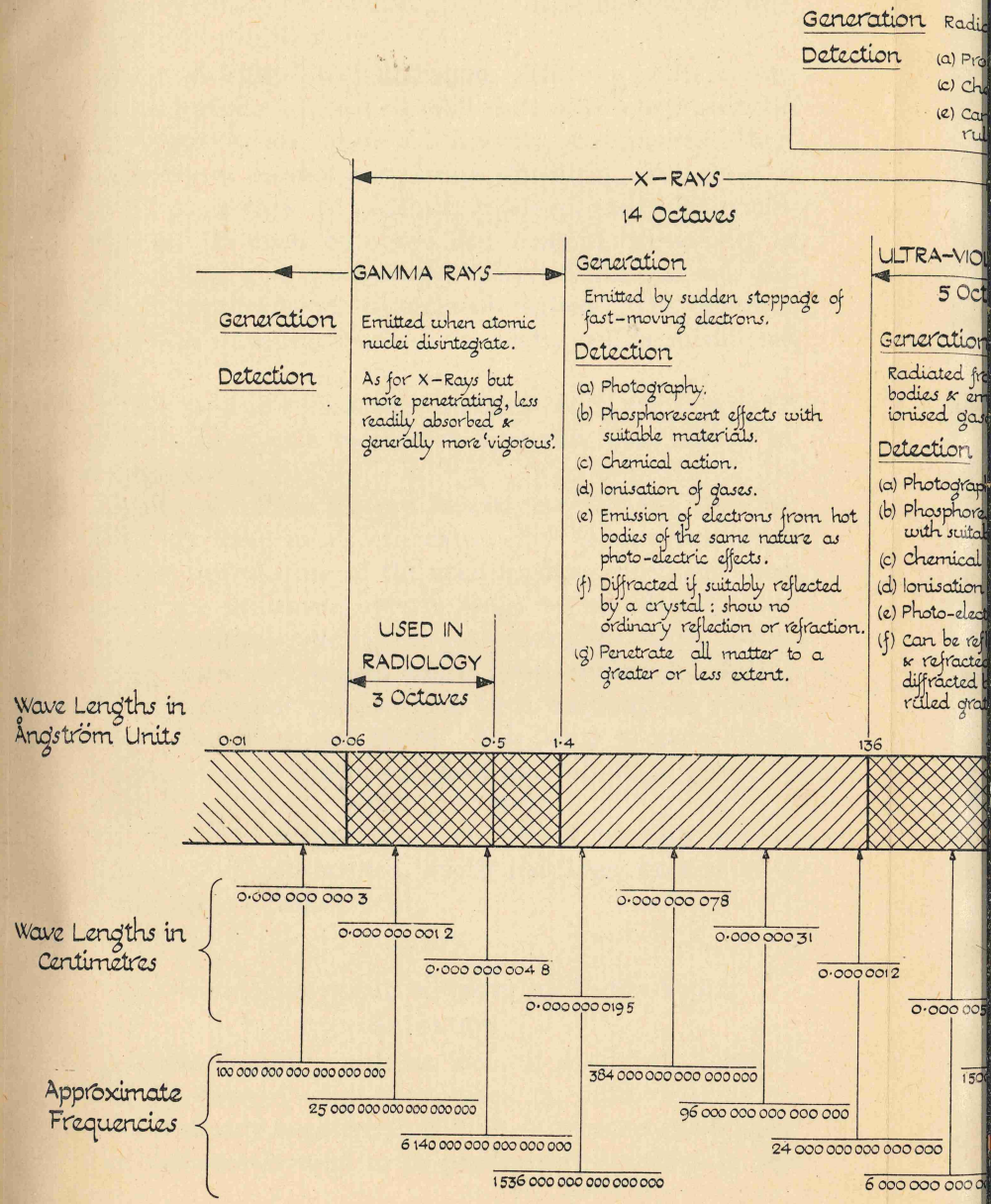

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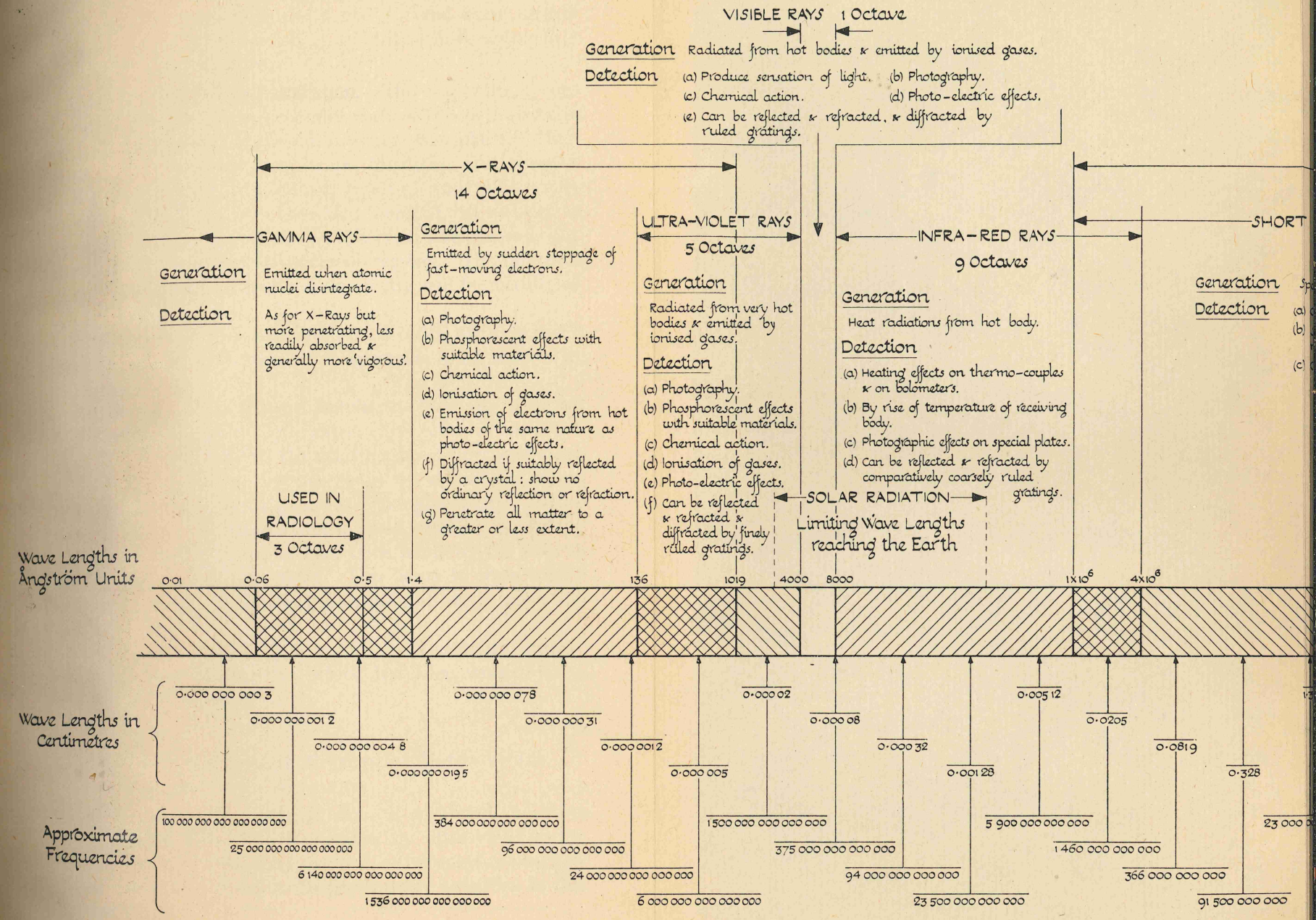

FIG. 1.

(Through the courtesy of the British Empire Exhibiti

ELECTROMAGNETIC WAVES

Velocity of 30,000,000,000 centimetres per second.

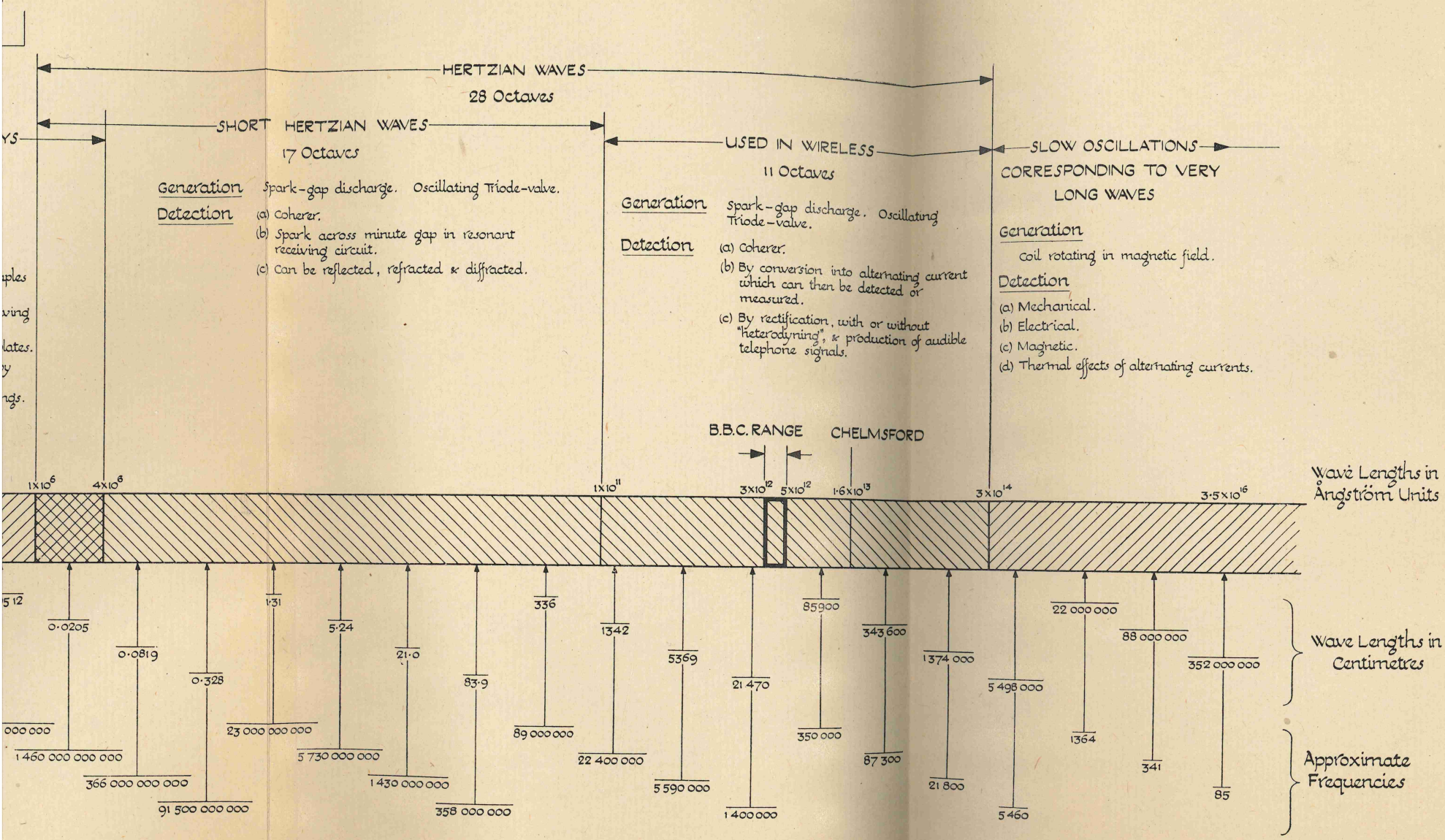

FIG. 1.

courtesy of the British Empire Exhibition Committee of the Royal Society.)

To face page 4

This left a very short space between the shortest ultra-violet rays and the longest X rays, as measured by crystal spectography, which ends about 13·3 Å.; and using certain metals as electrodes, Lyman and Millikan have apparently bridged this gap recently.

Source of Ultra-Violet Radiation.—The sun emits a continuous spectrum of great strength, but wave-lengths shorter than 2,950 Å. are absorbed by the atmosphere. Magnesium flares, incandescent lamps, limelight, arcs between metals, spark gaps, and vacuum tubes all emit ultra-violet radiation. It must be noted that none of the sources of artificial light give a *continuous* spectrum like the sun, but show absorption bands at different regions. The influence of different wave-lengths in these spectra will be mentioned later.

Finsen used an arc between iron electrodes, which is much stronger and gives a more even spectrum than carbon at the same wattage.

About 1901 Peter Cooper Hewitt evolved the mercury vapour arc lamp in an evacuated glass tube, which stood the high temperature of the volatilised mercury, and later evolved an evacuated quartz lamp which allowed 1,000 times more ultra-violet rays to pass than glass lamps. More recently a mercury vapour quartz lamp, working at slightly above atmospheric pressure, has been made by the firm of Kelvin, Bottomley and Baird. This lamp is more stable than the vacuum lamps, and does not fall off in power so rapidly.

At Harvard University a more recent mercury vapour lamp has been constructed, which has been worked at a pressure up to 5 atmospheres.

II. Photo-Electrical Effects of Ultra-Violet Radiation

A polished metal, such as zinc, if insulated, becomes positively charged when illuminated by ultra-violet radiation. If already negatively charged, it becomes discharged. The alkali metals seem to be particularly sensitive in this

respect. Hertz (1888) showed that when ultra-violet radiations fall upon a spark gap, the discharge takes place across it more readily. One is here tempted to suggest that this fact might be applied to the improvement of thermionic valves in wireless work by using quartz bulbs, and radiating the valve while in action with a beam of ultra-violet light.

Abiotic Phenomena occurring under the Influence of Ultra-Violet Radiation.—Marshall Ward threw the spectrum on an infected agar plate, and showed that no growth occurred in the parts of the plate irradiated by the ultra-violet end of the spectrum, while those parts exposed to the visible and infra-red regions showed growth. About 1900 Finsen found that the abiotic action of rays became markedly evident as soon as he reached wave-lengths shorter than those contained in sunlight. The industrial application of this property of ultra-violet radiation was closely associated with the development of the means of production of the rays, and advanced rapidly with the evolution of the quartz lamp. To-day ultra-violet radiation is used extensively for sterilising water in swimming-baths, and has been used to sterilise milk. It is interesting to note that bacteria do not vary in their resistance to ultra-violet radiation as they do to chemical agents and to heat. For instance, spores, which are often twenty times more resistant to other agents than ordinary unprotected water bacteria, are only one and a half to five times as resistant to ultra-violet radiation.

Mode of Action of Ultra-Violet Radiation on Living Cells.—Numerous theories abound as to the exact method by which ultra-violet radiation acts on living cells. It is generally conceded that the deadly action is due to some unknown quality inherent in the rays themselves, and not to the action of some poison formed by them. Burge showed that while liquefying bacteria are killed by ultra-violet radiation, the enzyme which produces the liquefaction is almost unimpaired. He also tried to demonstrate that the destructive action is due to coagulation of the bacterial protein. This coagulation was not always demonstrable.

Action of Ultra-Violet Light on Tissue Cultures in Vitro.—S. Kiaer* exposed a pure culture of connective tissue *in vitro* to the action of ultra-violet light. The culture was placed in a water-bath at a temperature of 38° C., and was separated from the source of light—a Kromayer lamp—by 3 cm. of water, a quartz square, and 3 cm. of air, to exclude the heat rays. Exposure of a twenty-four-hour culture for five minutes did not affect the subsequent growth of the tissue, but an exposure of eight minutes decreased the rate of growth during the next twenty-four hours; on subculture after this period the tissue grew normally. An exposure of one hour retarded the growth in such a way that the tissue did not recover its original rate of proliferation till after two or three subcultures had been made. Finally, an exposure of two to three hours definitely killed the fibroblasts. It was expected that a very small dose might actually stimulate the growth, but this was never observed, even with exposures of 0·5 second. From these experiments it appears that the action of the ultra-violet rays is to injure the cells; the lethal dose is about ten to fifteen times the inhibitory dose. In another paper† the author describes the use of embryonic chick heart. With this tissue he found that a small exposure of fifteen seconds to two minutes increased the rate of contraction. After a short lag period the heart cells began to beat faster; return to the normal rate occurred in three to twenty minutes. To show that this accelerating action was due to the ultra-violet rays themselves, he replaced the quartz square by a piece of glass which would filter off the rays; exposure under these conditions was without effect. Further, by covering the tissue with China ink, he found that the rays had no effect, showing that the action was not due to the production of a change in the surrounding medium. It may be concluded that the accelerating action of the rays on heart muscle is the result of the ultra-violet light itself.

If white of egg is exposed to ultra-violet radiation it coagulates. So does the protoplasm of the paramœcium and the vinegar eel (*Anguillula aceti*). One can watch the

* *C. R. Soc. de Biologie*, December 4, 1925, p. 1389.

† *Ibid.*, p. 1391.

death of the latter quite easily under the microscope. Movements become feeble in a few seconds, and after about thirty seconds' exposure to ultra-violet radiation the organism suddenly becomes still and is dead.

With white of egg the coagulation is not apparent till it is placed in a solution of calcium salts, when the coagulated portion is rendered visible. It would seem that the protein of the egg white is changed in such a way by the rays that it can combine with the calcium salts, and forms a coagulum.

Hill sums up modern theory as follows:

" The rays . . . knock off electrons from atoms and alter the electrical charge of the ultra-microscopical particles of the colloid protoplasm, which results in an aggregation of these particles. There follows chemical (molecular) change, which is of such a nature as to provoke . . . erythema, œdema, and lymphocytosis."

Hill and Eidenow have found an increase of the hydrogen-ion concentration accompanying the killing of infusoria with ultra-violet radiation.

The writer has found an increase in the hydrogen-ion concentration of the skin immediately after irradiation, using bromo-thymol-blue as an indicator. This increase seems to be in direct proportion to the degree of reaction obtained.

Russ has shown that the most effective abiotic region of the spectrum is in the " far " region of the shorter waves (" Schumann region "), wave-lengths 1,800 to 2,200 Å., although these waves have very little penetrative power and are stopped by 0·1 mm. of human skin.

Benoit has reported remarkable success in the treatment of war wounds by ultra-violet radiation, the description of the changes in the wounds closely following those produced by Sir Almroth Wright's hypertonic saline and citrate dressings.

The consensus of opinion seems to be that ultra-violet radiation kills living cells and tissues by changing in some way the protoplasm of the cells, so that certain salts can combine with the protein of the protoplasm to form an insoluble compound.

A wide field for research remains in the action of ultra-violet radiation as a means of sterilising bacterial suspensions for use as antigens. There is reason to believe that ultra-violet radiation of bacteria tends to favour a retention of antigenic properties while diminishing the toxicity of the organisms. It is well known that organisms, particularly those of the Gram-negative group, such as *B. coli*, etc., tend to produce rather irksome local and general reactions when killed by heat and used as a vaccine.

The writer is indebted to Dr. Lundie, of the Ministry of Pensions Laboratory, Birmingham, for help in the following experiment, and for the use of laboratory animals. Unfortunately the laboratory was closed, and so further work could not be carried out.

A week-old alkaline broth culture of *B. dysenteriæ*, Shiga, was taken, and 1 ounce was exposed in a Petri dish $4\frac{1}{2}$ inches under an atmospheric type mercury vapour quartz burner. Instrument readings were: Voltmeter, 250 volts; ampere meter, 2·6 amps.; thermometer ($4\frac{1}{2}$ inches from burner), 40° C.

Cultures.—Subcultures were made on agar at ten, twenty, and forty minutes during the exposure, and incubated at 37° C. The forty-minute subculture showed no growth. The twenty-minute subculture showed delayed and scanty growth after thirty hours' incubation. The ten-minute subculture showed some delay in growth.

Two c.c. of the broth after forty minutes' exposure proved non-toxic to a guinea-pig injected subcutaneously, whereas 2 c.c. of the non-irradiated broth produced peritonitis in another guinea-pig when injected in the same way.

The inhibitory power of ultra-violet radiation on a large mass of organisms in broth, as outlined above, suggests the utility of this bactericide in preparing toxic bacteria, such as *B. dysenteriæ*, Shiga, for antigenic purposes. Antisera might be prepared from these toxic bacteria more readily by building up an immunity by injecting bacteria or their toxins which have been exposed to the rays for constantly diminishing periods of time.

It will be noted above that the Shiga toxin had lost its toxicity after irradiation.

Diphtheria toxin is stated to behave in a similar fashion (Dr. Donald McCaskey, New York).

Diphtheria antitoxin, on the other hand, is most resistant to radiation.

Eberson states that prolonged shaking inactivates complement, leaving amboceptor unchanged, in a hæmolytic serum. On the other hand, ultra-violet irradiation inactivates both complement and amboceptor, while X rays do not affect either. Possibly this is due to the X rays penetrating the fluid easily, while the ultra-violet rays may be absorbed by the proteins. Agglutinins and antitoxins seem to be the most resistant antibodies to ultra-violet radiation.

Effects of Ultra-Violet Radiation on Human Skin.—Müller, of Tübingen, has constructed a new "skin microscope" which magnifies by about 40 diameters. The skin is smeared with cedar-wood oil and the microscope lens applied. A good site for observing is above the lunule of the nail. The observer can see down to the subpapillary plexus. Dilation of capillaries after ultra-violet irradiation was observed, and this was found to persist for a week after exposure to the quartz lamp of five to fifteen minutes. Pigment could also be studied. The skin microscope showed that when light is applied, the body sets about preparing a protective mantle of pigment as soon as it can after the light stimulus is applied.

This stimulus, if too sudden or too severe, causes the protective mechanism to resolve itself into an intense hyperæmia, or, as Nieukau puts it, "the body hoists a red umbrella."

Browning and Russ performed some interesting experiments with sections of human skin taken from the abdominal wall, using layers $\frac{1}{10}$, $\frac{1}{2}$, and $1\frac{1}{2}$ mm. thick. These were placed in front of the spectrograph slit, using a Simpson arc at 20 cm. distance as the source of ultra-violet radiation. They showed clearly that the skin was very absorbent for wave-lengths between 2,100 to 2,960 Å., while from 2,960 to 3,800 Å. the waves were more penetrative, but not markedly so. In the first band of shorter wave-lengths

a very small amount of ultra-violet radiation reached $\frac{1}{10}$ mm., and the longer wave-lengths probably did not penetrate as deep as 1 mm.

Russ has shown also that the shorter wave-lengths are highly bactericidal, and have a sterilising effect on skin surfaces exposed to them. Longer wave-lengths have not the same power.

Perhaps the most striking effect seen on skin is the erythema which results from exposure to ultra-violet radiation. After a well-defined latent period, which varies from four to eight or ten hours, an erythema appears. (This latent period has not yet been satisfactorily explained.) The personal idiosyncrasy of the patient causes this erythema to vary enormously. Other factors involved are the richness of the source of ultra-violet radiation, the time of exposure, the distance of the skin from the source of light, and the temperature of the room. Here, again, the short wave-lengths, below about 3,200 Å., are alone responsible for the erythema. If screens of various sorts—3 per cent. quinine solution or thick window glass—are used, no erythema results, because only the longer waves have passed. The erythema varies from the faintest flush to a markedly intense redness, which may last for eight or nine days, and is followed by definite and profuse peeling, accompanied by much irritation and sometimes œdema. If the dose is severe, actual blisters may form. These, however, heal up, leaving no scar. This erythema is apparently due to profound changes in the superficial epithelial cells of the skin. It is accompanied by *marked dilatation of the superficial capillaries*, which may dilate to double their size or even more—four to five fold. The capillary blood slows down, and may even come to a standstill. Twenty-four hours after there is diapedesis of leucocytes from the deeper vessels. If the exudation is sufficient, continuity between the horny and granular layers of the epidermis is broken, and a blister results.

Pigmentation.—Following on the erythema we get desquamation, followed by pigmentation of the skin. This varies enormously with individuals, and also with the type of lamp used and the amount of erythema preceding it.

In general, carbon arc lamps produce a deeper pigmentation or bronzing (like "sunburn") than mercury vapour lamps. In the latter, the pigmentation is slight and more yellowish. After repeated exposures to the mercury vapour lamp the skin seems to lose its light sensitiveness, and pigmentation remains slight.

Hill and Eidenow state that pigmentation appears to be directly proportionate to the intensity of ultra-violet rays between 3,200 and 2,500 Å. The pigmentation of the skin is due to melanin, which is deposited as granules round the nuclei of the epithelial and basal cells. Melanin apparently acts as a screen, preventing excessive heating of the blood from the luminous and infra-red rays, and also screens the ultra-violet rays. Hill states that melanin powder, extracted from the retina of the ox and mixed with water, will protect the palm of the hand against the sun's rays focussed with a burning glass. He states that such a suspension absorbs all except the red end of the spectrum. It is true that melanin will protect against the luminous and the ultra-violet rays, but it is difficult to reconcile this statement that protection exists against the infra-red rays if it transmits red rays. Given a pigmented skin, very much longer and greater doses of light may be given for longer periods, and the erythema dose is considerably larger. Brunettes and dark-skinned subjects are, as a rule, much more tolerant to light than blondes.

Photo-Dynamic Substances.—The whole question of light sensitiveness is one of absorbing interest and of great practical importance in the therapeutic application of these rays. Apparently no two persons are exactly alike in their sensitiveness to ultra-violet radiation. Even the hairs on the body respond differently to irradiation. The beard grows more rapidly during the day on which the operator irradiates his patients. Hairs on the forehead, on the other hand, are apparently not stimulated. The sun's rays can produce acute solar dermatitis, for which the actinic rays are solely responsible, as it occurs from the cold reflected rays in a snowfield. Certain substances, described as "photo-dynamic substances," have the power of rendering individuals extremely sensitive to sunlight or ultra-violet radiation. Amongst these are eosin, methylene blue, fluorescin, hæmatoporphyrin, chlorophyll, and some of the heavy metals (gold, silver, iron, mercury, etc.).

Hydroa Æstivale is a recurrent eruption affecting the parts of the skin exposed to sunlight, and is characterised by the presence of vesicles and papules, and even blebs, and is most marked in the summer. In several cases J. M. H. MacLeod claims to have discovered hæmatoporphyrin in the urine and in the blood serum during an attack. MacLeod suggests that other obscure diseases, such as pellagra and xeroderma pigmentosum, are associated with some toxic substance which renders the skin supersensitive to light. Betz injected into himself intravenously 0·2 grm. hæmatoporphyrin, and detected it in the urine and blood serum shortly afterwards. He became and remained extremely sensitive to light for several months. This is a most important contribution to the subject of light sensitiveness. Eosin in 1 per cent. aqueous solution has been stated to be of use in the treatment of lupus patches, rendering them more sensitive to ultra-violet radiation, and enabling one to obtain stronger local reactions on the lupus patch. The writer's experience has not confirmed this. W. Duke reports a case of remarkable sensitiveness to sunlight in a woman aged forty-three. This sensitiveness commenced to develop four years previous to her being seen by him. Wheals on the skin appeared in five minutes after being exposed to sunlight for two and a half minutes. He adds that this effect was *not* produced by heat, X rays, nor by ultra-violet radiation from a quartz lamp. Neither the urine nor the blood serum showed any hæmatoporphyrin, nor any other photo-dynamic substance. Hydroa may exist without porphyrinuria, but Garrod and Mackey point out that porphyrin may be present in the fæces and not in the urine. Where porphyrin is not detected, it must be assumed that some other photo-sensitising agents are present. Porphyrinuria is stated to be a very rare condition. The pigment would appear to be an intermediate product between blood pigment and bile pigment, and is present in the ante-natal meconium.

Red Blood Cells and White Blood Cells.—The red blood cells act as a screen to ultra-violet radiation, the hæmoglobin absorbing the rays, and thus protecting the blood fluids from the destructive effect on complement and amboceptor, as mentioned above. Under ultra-violet radiation red blood cells slightly increase in number, and the hæmoglobin content also increases after continued treatment. Generally speaking, one has found an increase in leucocytes after even one dose, about two to four thousand, reaching its height in about four to five hours after exposure. Differential counts show this increase to be mainly lymphocytic in type. All published results agree that ultra-violet radiation stimulates a lymphocytosis in man and animals. Colebrook, Eidenow, and Leonard Hill showed that when the skin was mildly irritated with ultra-violet radiation, radiant heat, or mustard baths, there was a definite increase in the bactericidal power of the blood. Red blood cells are protected from ultra-violet radiation by the serum; on the other hand, if suspended in saline, they are readily hæmolysed by ultra-violet radiation.

Dr. Eidenow has shown more recently that exposure of defibrinated blood *in vitro destroys* its bactericidal properties. On the other hand, when this irradiated blood is reintroduced into the circulation, an augmentation of the bactericidal power of the circulating blood is obtained. These workers attribute this augmentation of bactericidal power in blood to improved functions of the leucocytes.

If irradiation is too severe, the above investigators were able to demonstrate a *deterioration* of the blood no less striking than the improvement obtained with suitable doses. This observation has been borne out in the writer's experience clinically, and in several cases where slight overdoses of ultra-violet radiation have been given, slight but definite untoward results were forthcoming. This was observed chiefly in irradiation given to cure or abort a "cold."

In several cases the "cold" got rapidly and surprisingly worse, and was accompanied by headache, torpor, and lassitude, with nervous irritability. On the other hand, suitable doses often succeeded in cutting short an acute

coryza, and preventing it conforming to the type prevalent at the time.

Action on Blood Platelets.—Dr. R. G. Bannerman, working at Montana in Switzerland, reported to the Medical Research Council during the year 1924 that a hot sun-bath, which raises the general temperature, is followed by an increase in the number of blood platelets. This effect is also obtained after a hot bath, and this would suggest that heat is the important factor. The blood platelets are found to be decreased in infections such as acute coryza, measles, and influenza, and much increased in pulmonary tubercle.

Cramer and Drew have found that blood plates are abnormally small in numbers where animals are kept in the dark from birth. Ultra-violet radiation will cause an increase in the plates in such animals. Platelets are found to be diminished in rickets and in animals starved of vitamin A.

The relation of platelets to various infective conditions is obscure, but ultra-violet radiation is known to increase their number.

It has been stated that an overdose of ultra-violet radiation will reduce the platelets. Possibly this partly explains the bad effects of an overdose in acute coryza, where the blood platelets, already low, may be further depressed.

Absorption of Ultra-Violet Radiation by Blood Sera.—Serum contains about 8 per cent. proteins, including albumin, pseudo-globulin, and euglobulin.

Judd-Lewis investigated the contribution made by each protein constituent of serum to the ultra-violet absorption spectrum curve of blood serum. He used a new sector spectrophotometer of improved design, and after separating the three proteins, examined each in a 2 cm. observation tube with quartz ends, using 0·08 per cent. solution in distilled H_2O for albumin, and 0·04 per cent. for the pseudo-globulin and euglobulin. Absorption curves were plotted with extinction coefficients as ordinates and wave-lengths as abscissæ. He showed that the absorption curve of pseudo-globulin is constant, and is the same for horse and man.

The absorption curve for euglobulin differs considerably from that of pseudo-globulin in extinction coefficients, but not in its general form. As regards albumin, the absorption curves for horse and human varieties are shown to be the same, except for a constant ratio in their magnitudes. He suggests that this may be due to the physical, and possibly chemical, association of an aggregate possessing little or no selective absorptive power with the principal or absorbing aggregate.

Comparisons between the absorption of the proteins of human serum and horse serum reveal absorption bands somewhat greater in dimensions for the latter than for the former. It is obvious that the above facts explain the protection of red blood cells by the blood serum against hæmolysis by ultra-violet radiation.

Effects of Ultra-Violet Radiation on the Calcium and Phosphorus Content of Serum.—In normal children the inorganic phosphorus in the blood serum is about 5 or 6 mg. per cent., while the calcium content is somewhere near 10 mg. per cent.

It has been quite definitely established by numerous workers that rickets is associated with a diminished calcium and inorganic phosphate content. In rachitic children it is usually the inorganic phosphate which is low, and it may fall as low as 1 mg. per cent.

Hess, working on the blood of New York children, claims that there is a seasonal variation of inorganic blood phosphates, which falls during the winter up to March, and rises again in the spring to a maximum in the late summer. Hess has demonstrated a rise in the inorganic blood phosphate of rachitic children following ultra-violet radiation treatment. This has been amply supported by other observers, and occurs within two weeks of beginning treatment. The calcium content of the serum is also notably increased by ultra-violet radiation, particularly in the case of infantile tetany treated with light. In rickets the blood calcium is often reduced. In tetany it is always reduced, and may fall as low as 3·5 mg. per cent. Calcium therapy helps symptoms, but the calcium content in serum does not quite

attain normal. With ultra-violet radiation treatment, however, the blood calcium can be raised to practically normal, and this also within an average period of two weeks, as in the case of phosphorus. McCollom states it is not a diminution of phosphates which matters in rickets, but a disturbance of the normal ratio between calcium and phosphorus. This is the more modern view.

III. Photo-Chemical Effects of Ultra-Violet Radiation

Ultra-violet radiation is very active chemically, and over one hundred years ago Theodor von Grotthus formulated the law of photo-chemical absorption—viz., "that only the rays absorbed are effective in producing chemical change."

Professor E. C. C. Baly, speaking on the conception of "high energy" chemistry as opposed to "low energy" chemistry—the everyday reaction of inorganic chemistry—conceives three separate stages in every chemical reaction:

1. The activation of the reactant molecules by the supply of a definite and specific increment of energy.
2. The reaction proper, whereby new molecules are produced in an activated condition.
3. The loss of energy by the resultant molecules, whereby they settle down into their normal state.

He instances the action of ultra-violet radiation on carbonic acid as an example of "high energy" chemistry, and states that the first stage is the conversion of the carbonic acid into formaldehyde:

$$H_2CO_3 = HCOH + O_2.$$

This is transient, and when means are taken to remove the oxygen the reaction proceeds. The formaldehyde polymerises and gives hexose sugars:

$$6H_2CO_3 = 6HCOH = C_6H_{12}O_6 + 6O_2.$$

This is probably the first stage in photo-synthetic processes in living plants. In plants the oxygen is removed by the four pigments—the two chlorophylls, carotin, and xanthophyll. The two former are credited with enabling

the reaction to take place with visible light and the relatively small amounts of ultra-violet rays available in sunlight.

Baly insists on the great importance of the hydrogen-ion concentration in these reactions, suggesting that this factor determines the different types of alkaloids produced by the action of photo-synthesis in plants.

Thus we have learned that light can change a substance to a state of higher energy content and maintain it in that state, and also one can observe the emission of energy when the reverse change takes place. During the reverse change the energy is sometimes emitted as visible light (phosphorescence or fluorescence), or by the long wave radiation in the infra-red, which is invisible (heat).

Ultra-violet radiation readily affects the decomposition of alcohols, aldehydes, organic acids, and ketones, and gives polymerising effects in the case of acetylene, ethylene, cyanogen, and oxygen, causing a diminution in volume. The activity of photolytic decomposition decreases markedly as the weights of the compounds increase.

Ultra-violet radiation has a stronger action in producing phosphorescence and fluorescence than visible light. When the luminous visible rays of a quartz mercury vapour lamp are cut out by means of a dark glass containing nickel, the ultra-violet rays are demonstrated to be invisible in a dark room. A piece of uranium glass introduced into the invisible beam is seen to fluoresce beautifully, and the amount of penetration of the ultra-violet rays into the block of uranium glass can be seen and measured. If this invisible beam is directed on the skin, a generalised violet fluorescence is seen, especially over the teeth and nails. On the face numerous small non-fluorescent spots are observed, and also small brightly-fluorescent spots. Very beautiful effects are produced on a wide range of substances, such as salicylic acid, oils, and starches. Dead teeth absorb the rays almost completely, and appear quite black.

CHAPTER III

ULTRA-VIOLET RADIATION IN THE TREATMENT OF DISEASE

(*a*) Choice of Source of Ultra-Violet Rays

It should be realised that there is a quite definite limit to the available wave-lengths from the sun, owing to the absorption of all rays shorter than about 2,950 Å. Apart from the scanty amount of sunlight obtained in these islands, the intensity of sun radiation received is subject to so many variations owing to cloud, smoke, and temperature, that more and more reliance has been placed in recent years on artificially produced ultra-violet rays. Moreover, sun radiation has a very large proportion of heat rays, which in some cases may be harmful. With an artificial source of ultra-violet radiation the factors are reasonably constant, and can be reproduced at will by adjustment of voltage, amperage, temperature of room, time, and distance of the irradiated subject from the lamp. The rays at the red end of the light spectrum are 7,500 Å.; those at the violet end are 3,900 Å. At this point commences the ultra-violet rays. For practical purposes we are interested in those wave-lengths down to 1,850 Å. The air absorbs waves shorter than these, and so shorter waves cannot be used for therapeutic purposes. For purposes of treatment the chief region lies between 1,850 and 3,900 Å. Sun lamps emit a number of rays of different wave-lengths, giving rise to different effects—heat rays, light or luminous rays, and ultra-violet rays.

(i.) **Heat Rays** warm the skin and produce sweating. If severe, they produce a burn, but ample warning of this is given by the patient's sensory nerves. They penetrate the tissues to a considerable distance—10 to 14 cm.

The Therapeutic Use of Infra-Red Rays.—C. Benoit* states that the infra-red rays which immediately succeed the red or red-black rays in the spectrum have a much greater power to penetrate the tissues than the ultra-violet rays, their penetration being 1 to 3 cm., and even more when the irradiation can be prolonged. The penetration increases as the wave-length increases. The tissues show a varying degree of permeability by the infra-red rays. After the skin the muscular tissue is most readily permeated, and then the cellular tissue, aponeuroses, and bones. Blood, on the other hand, absorbs and arrests the rays. Serous membranes, which contain a certain quantity of fluid, and especially morbid effusions, show considerable resistance to the rays. The penetration of the rays varies with the sensitiveness of the subject under treatment, some tolerating the sensation of heat better than others. Infra-red rays give rise to intense hyperæmia, with redness of the skin in the zone irradiated. The redness is sometimes uniform, but may present dark streaks on a lighter background. The redness persists for a long time—as a rule two to three hours, and sometimes eight to ten hours—and then progressively fades, the darkest streaks being the last to disappear. The local temperature after cessation of the irradiation sometimes remains high for as long as two hours. Infra-red rays have an important action on the bloodvessels and their contents, causing marked vaso-dilatation, a progressive increase in the number of red corpuscles, a marked diminution of the leucocytes, and an increase in the temperature of the plasma. Lastly, they exercise a remarkable analgesic effect, which is due partly to the hyperæmia and vaso-dilatation accompanying the irradiation, and partly to the action of the radiations on the nerve endings in the dermis.

(ii.) **Luminous Rays** have many photo-chemical properties. They can penetrate the skin to the deeper layers, and are said to raise the temperature of these deeper layers by 3° or 4° C., and thus may increase lymph circulation. They have practically no direct bactericidal action, and do not produce erythema or sunburn.

* *Revue d'Actinothér.*, October-December, 1925, p. 61.

(iii.) **Ultra-Violet Rays** have definite and marked photo-chemical and photo-electrical properties. They are invisible to the eye, and yet produce marked erythema and sunburn after a definite latent period of six or eight hours. No warning of this result is given by the patient's sensory nerves during the period of irradiation. They are markedly bactericidal to surface organisms, but penetrate the skin to a very slight extent—$\frac{1}{10}$ mm.

The type of lamp here discussed will, in the first place, be *one intended for general treatment* as opposed to local treatment of restricted areas and small cavities. We have the choice between the ordinary arc lamp and the quartz mercury vapour lamp. From the point of view of a health officer dealing with lay committees and concerned with expense, a point also of interest to the general practitioner, it is useful to compare the two.

The Ordinary Arc Lamp.—Intensity of radiation seems to depend on the length of the arc. The quality of the radiation depends on the type of electrode used. Tungsten and metal-cored carbons emit shorter ultra-violet radiations than plain carbons (" far " ultra-violet region). Iron electrodes give a spectrum which approximates to a continuous arc like that of the sun. The carbon arc emits a very intense radiation in the " near " ultra-violet region just beyond the violet end of the spectrum, which has the greatest skin penetrative powers, but is not so rich in the shorter and more bactericidal ultra-violet radiations obtained from the tungsten and mercury vapour arcs.

The arc lamp emits considerable *heat*, and in the case of the tungsten electrode arc, most irritating fumes. The electrodes have to be adjusted as they burn, either by hand or by some sort of mechanism. They burn away at the rate proportional to the wattage used, and so have to be renewed. Some of these lamps splutter and are apt to burn the patient. The large arc lamps are costly in initial expense and upkeep, and are difficult to adjust to constant intensity. They take from 50 to 60 amperes per lamp. Patients have to be exposed for long periods to these lamps, as they cannot sit too near them.

The Quartz Mercury Vapour Lamp.—This lamp is very rich in ultra-violet rays, especially at the "vital" region of the spectrum, 2,400 to 3,100 Å., but is not so powerful in heat rays. Its spectrum shows a very marked selective luminous ray (green and yellow).

There are two types on the market—one the vacuum type, and the other a type of lamp working at atmospheric or a little above atmospheric pressure. Some of the vacuum types are very inefficient, and all vacuum types tend to grow weaker as they are used. After about 800 hours the lamp has to be cleaned and re-exhausted. On the other hand, the atmospheric lamp is rather more powerful, having an intensity of about 3 to 2 compared with the vacuum type of similar size. It is automatic in action, and does not require renovation under 1,000 hours.

After removing the mercury with a vacuum pump, cleaning the reservoirs out with nitric acid, and replacing the mercury, the lamp is ready for use again. This lamp starts up on 4 to 5 amperes, and in a few minutes settles down to burn at 2·6 amperes. The lamp is silent, does not give off much heat (40° C. at $4\frac{1}{2}$ inches), and is exceedingly efficient and cheap to run—under 4d. per hour (220-volt type).

If used unscreened, six patients may sit round it comfortably. Relatively short exposures are required to obtain apparently similar effects to those produced by the bigger carbon or similar type arc lamps.

Turning now to the question of local treatment, surface lesions involving relatively small areas may be treated by the above lamps, and erythemata from mild redness to blistering burns may be obtained with a quartz lens mounted in a holder of wood and pressed down on the lesion, thus securing local blanching of the skin and obtaining greater penetration of the rays. For the treatment of mucous membranes and cavities of the body, however, we are restricted at present to the use of the quartz mercury vapour lamp of the vacuum type mounted in a metal globe and cooled by a system of water circulation. A quartz window in the globe emits through a system of quartz lenses a small beam of intense light of short focal length. Such lamps are

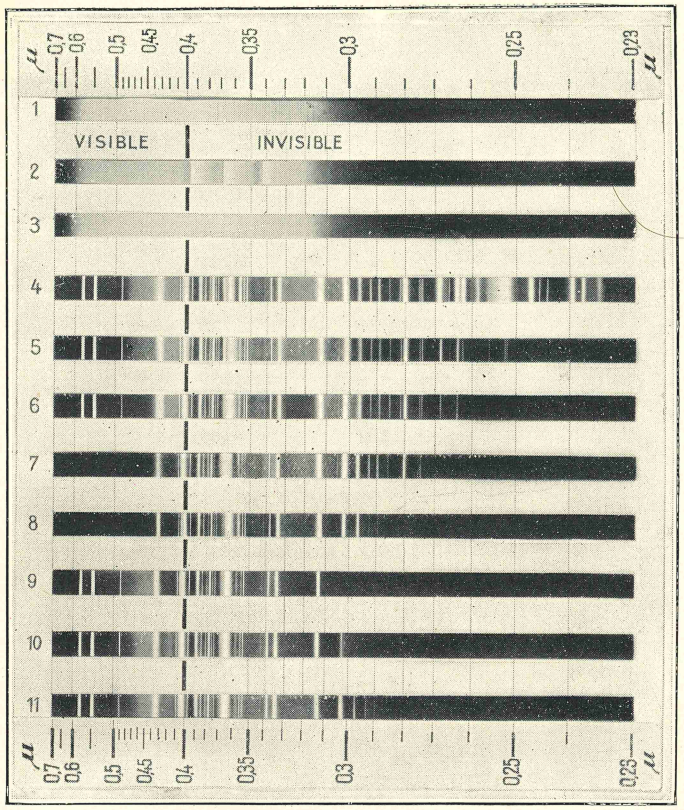

FIG 2.—SPECTRA OF DIFFERENT SOURCES OF LIGHT

The spectra shown were obtained from exposures of similar negatives for the same time.

Wave-lengths in millimicrons (1μ equals 10 Angstrom units): 1. Sunlight (at sea level); 2. Carbon Arc Lamp; 3. Sollux Lamp (Woltram filament); 4. "Alpine Sun" Quartz Lamp (without fitter); 5. "Alpine Sun" Quartz Lamp through 1·3 mm. white Uviol glass; 6. "Alpine Sun" Quartz Lamp through 2·6 mm. white Uviol glass; 7. "Alpine Sun" Quartz Lamp through 1 3 mm. blue Uviol glass; 8. "Alpine Sun" Quartz Lamp through 2·6 mm. blue Uviol glass; 9. "Alpine Sun" Quartz Lamp through thin window glass (1 mm.); 10. 'Alpine Sun" Quartz Lamp through 0·25 mm. celluloid sheet; 11. "Alpine Sun" Quartz Lamp through 0·05 mm. mica sheet.

By courtesy of the British Hanovia Quartz Lamp Co., Ltd., Slough.

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rather fragile and liable to small troubles and inconveniences, and are costly. In the near future an air-cooled burner of atmospheric type mounted in a special shield will be available for local work. This will be relatively cheap in initial cost, and may be used for the dual purpose of general irradiation (with shield removed), and for local applications in restricted areas.

(*b*) Dosage

Definite guidance as to the correct dosage of ultra-violet radiation is in a much less developed stage than in the case of the X rays. The most easily observed clinical effect of the ultra-violet rays is the production of erythema, and in this respect the dosage is bounded by fairly narrow limits. Lamps, even of the same size and make, vary amongst themselves, and each lamp tends to lessen its ultra-violet ray output the longer it is used. Patients, too, vary enormously in their sensitiveness to ultra-violet radiation. The administration of either excessive or insufficient doses is very apt to result.

In treatment, the aim may be, broadly speaking:

1. To improve the state of the patient by general irradiation.
2. To attack local lesions.

In the former, as a rule, the best and quickest results are obtained by the production of a very mild erythema, which lasts a few hours and leaves no desquamation; while, in the latter, one tries to obtain a more marked counter-irritant effect, ranging from a deep erythema to a blistering burn.

For clinical purposes it is convenient to classify erythema reactions into four groups:

Reaction, first degree: Simple, mild reddening of the skin.

Reaction, second degree: Reddening of the skin followed by slight itching and powdering of the skin.

Reaction, third degree: Marked reddening of the skin, discomfort, some œdema, followed by profuse peeling.

Reaction, fourth degree: Profound irritation of the skin, with formation of blisters and œdema.

Actinometers.—Actinometers do not help very much in dosage, but they are of great assistance in checking the ultra-violet ray output of a lamp or lamps. In actual practice the writer's plan is to secure an oblong piece of thick cardboard and cut five small windows in it. This is laid on the patient's abdomen, and another slip of cardboard superimposed. As this is drawn to the left, each succeeding aperture is uncovered to the rays of the lamp at 1 foot distance for one minute, or if one suspects that the patient is tolerant, for two minutes. Thus, in the latter case we have five small areas exposed ten minutes, eight minutes, six minutes, four minutes, and two minutes respectively at 1 foot. Next day these can be inspected.

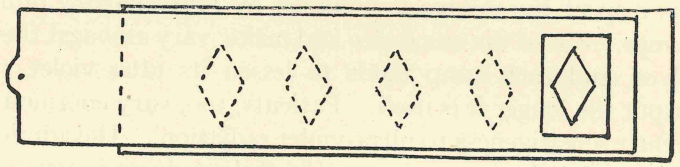


FIG. 3.

A suitable initial dose for general treatment is three-quarters to one minimum erythema dose. The rule is that the effects of the lamp vary inversely as the square of the distance of the object from the lamp. With test areas, as above, there is very little difficulty in deciding upon the time and distance, depending on the type of treatment desired. If many patients are treated and time forbids the use of the above method, as a general rule it is usually safe to begin with a light bath of three minutes at 3 feet with the average quartz lamp running on 220 volts circuit.

In some cases improved results may be obtained by general mild irradiation, and at the same sitting production of a definite erythema over a localised area.

Eidenow and Hill state* that at least 15 square cm. of skin per kilo of body weight is the minimum of skin area which must be irradiated to produce an increase in the bactericidal power of the blood.

These authorities state that the minimum erythema dose

* Eidenow and Hill: *Practitioner*, August, 1925, p. 106.

in a normal white skin corresponds to twice the time required for killing a standard culture of infusoria in a standard quartz cell at a temperature of 20° C. They express the power of a lamp in infusoria killing units (I.K.U.). Various actinometers have been suggested for comparing the ultra-violet intensities of various lamps. Hill suggested the use of a solution of 30 per cent. pure acetone coloured with methylene blue. This is bleached by ultra-violet radiations, and is compared with a scale of coloured tubes biologically standardised. One on the scale equals twice to four times the dose required to produce an erythema of white skin.

A great deal of stress has been laid by numerous writers on the importance of the production of erythema in light therapy, and in the development of pigmentation. The author believes that too much attention has been paid to these statements. In actual practice it has been found that many patients, particularly young children and babies suffering from malnutrition, debility, or rickets, showed rapid and complete improvement without evincing the slightest erythema.

Another common assertion is that the degree of pigmentation obtained is an indication of the resistance of the body to disease. This is entirely erroneous. Observation of any group of patients treated with light will show that some of them with similar colouring and complexions will pigment more than others quite irrespective of the condition of their general health.

Pigmentation is much more marked with carbon arcs, and these remarks apply to patients treated with quartz lamps, where beneficial results are obtained with slight pigmentation, or, more commonly, with no pigmentation at all.

Pigment is protective to the skin, and in practice it is found more useful to retain the light sensitiveness of the skin, rather than diminish it by the establishment of deep pigmentation. Indeed, an excessive exposure resulting in a marked erythema confers an immunity on the skin treated, and it is often difficult to repeat the result without great increase in dose. A complete rest of the immune area of skin, however, results in a restoration of sensitiveness.

Rollier holds that pigment acts as a transformer of light energy in the tissues, which liberates more beneficial radiation. Against this view is the well-known fact that in New York City negro babies more often develop rickets than white babies.

Apart from the above results of exposure, and probably a much safer guide to proper dosage, is the subjective state of the patient. Excessive dosage, apart altogether from any question of whether erythema was produced or not, shows itself by a feeling of weakness, malaise, irritability, sleeplessness, or loss of appetite. On the other hand, suitable doses in the same patient are followed by a definite feeling of *bien-être*, increased vigour and cheerfulness, an increased capacity for work and play, and improved appetite and energy.

(*c*) Dangers

Memories of the untoward results met with by early workers with X rays have suggested the possibility of similar undesirable phenomena in the use of ultra-violet rays.

In a letter to the *British Medical Journal*, dated March 28, 1925, p. 631, Sir Lenthal Cheatle and Dr. Heald uttered a note of warning regarding the application of ultra-violet radiation treatment, and hinted at the possibility of remote effects, such as the production of epithelioma. He stated that with Dr. Arthur Whitfield he had examined sections of "bronzed" skin after ultra-violet radiation treatment, and found mitosis occurring in epithelial cells of the basal layers of the skin, from which he seemed to conclude that there might be a risk of inducing epithelioma. This letter was followed by a statement from Dr. Rollier, of Leysin,* who pointed out that as the irradiations produced an increase of all the vital phenomena of the skin, it was not extraordinary that the generative layers of the skin should present more numerous mitoses. He had never seen cutaneous epitheliomata occur in any case of lupus treated only by heliotherapy.

Dr. Sequeira, of the London Hospital, has often uttered

* *British Medical Journal*, May 9, 1925, p. 203.

warnings of the dangers of epithelioma being produced in scaly lupus through prolonged treatment by X rays, but he stated that in twenty-three years he had never seen harm to the skin of this nature after use of the Finsen light.

Dr. Axel Reyn states that amongst thousands of patients who have received photo-therapeutic treatment for lupus at the Finsen Institute, no case of lupous carcinoma has been met with due to the treatment. On the other hand, he claims that the percentage of lupous carcinoma in their records is the lowest existing. If the ultra-violet radiations were provocative, this would not be the case.

Dermatitis.—Drs. McCormac and McCrea* drew attention to the dangers of unqualified and untrained persons using powerful remedial agents, and quoted the case of an old man who went to sleep under a mercury vapour lamp while treating himself, with the result that he developed a most severe dermatitis. An interesting point was that the dermatitis appeared both back and front. One can only surmise that the old man turned over in his sleep, for in the course of one's experience in no case has a marked erythema on the side of the body exposed been accompanied by an erythema on the unexposed areas.

Accidents of the above type are rare, but due care must be exercised with individual patients. One has seen a very few light-sensitive patients who developed a marked third degree erythema, and who had to lie in bed for a few days. These patients felt depressed, languid, and out of sorts; the skin was very tender and œdematous, and there was profuse and repeated desquamation; but recovery was complete. Even in cases where a local blistering burn was produced, complete healing without scarring always resulted.

Discomfort in such cases may be reduced by the application of hamamelis compress, or the application of some simple ointment. Such untoward results are most likely to occur in patients who have absented themselves, and then returned and slipped into the treatment room, continuing at the old exposure, or getting an increase of dose.

* *British Medical Journal*, April 11, 1925, p. 693.

Malaise.—Every now and then one meets with a type of patient who complains of drowsiness almost immediately after a light-bath, with a few hours later a feeling of loss of energy, appetite, slight headache, irritability, and perhaps sleeplessness at night and loss of weight. These symptoms may persist for several days, and may be provoked by what would appear to be perfectly safe doses—doses which have produced not the slightest visible effect on the skin. They are chiefly evinced by patients with glycosuria, pulmonary tuberculosis, asthenia after debilitating diseases such as influenza, coryza, or diphtheria, or in patients with unexplained pyrexia. In every case, without exception, where such symptoms were met with, the blood pressure, both systolic and diastolic, was low.

Observations of blood pressures taken before and just after a light-bath showed that in the great majority of persons the systolic pressure is lowered from 6 to 8 mm., while the diastolic pressure is either unchanged or is lowered 2 to 4 mm.

In some of the tuberculous patients, where the above symptoms developed, it was deemed advisable to stop the light-baths. In the asthenic type of patient minimal doses very gradually increased were found to produce quite different results, the malaise, etc., being replaced by a feeling of marked well-being and mental alertness. In such cases, however, the dividing line between a suitable dose and an overdose is very fine indeed, and there is no safe margin for error. The following will serve as an example:

Case R. C. (Female, Twenty-four Years): Tuberculous Iritis.—Four years ago had redness and pain in right eye; lost sight in right eye in twelve months; left eye commenced to trouble her in same way six months after the right; left iris œdematous, with small nodules present. No chest symptoms, but X ray showed increased shadows at roots of lung. Treated at Birmingham Eye Hospital. Bad tuberculous history; decided to augment local treatment from hospital by general ultra-violet radiation, and in view of X-ray findings to give very small doses.

Feb. 9, 1925: One minute at 4 feet to back and front of body was followed by languor and anorexia; no erythema of any degree noticed.

Feb. 11, 1925: One minute at 4 feet, same result; blood pressure: 110 systolic, 64 diastolic.

Feb. 13, 1925: Time reduced to half a minute at same distance; immediately patient felt brighter and more energetic, and weight increased slightly.

By February 18, 1925, she had returned to one-minute doses, and by February 25, 1925, got to two-minute doses, when faint erythema appeared. By February 25, 1925, she reached three-minute doses, and the hospital authorities reported improvement in the eye condition.

It is probable that ultra-violet radiation produces untoward symptoms in patients suffering from adrenal exhaustion, as, indeed, the diseases mentioned above seem to be followed by such a condition.

Dr. F. Talbot, in a letter to the *British Medical Journal*, relates how an asthmatical boy was given an ultra-violet radiation bath, and also his brother, who was not asthmatical. Within some hours the first mentioned developed an attack of asthma, and showed a much milder erythema than the brother. He was given adrenalin. Within half an hour the asthma had passed off, and three and a half hours later it was observed that his erythema had increased and was now almost as marked as in the case of his brother. Dr. Talbot suggests that the skin's reaction to light makes a demand on the adrenals, which in this case temporarily exhausted them and induced the attack of asthma, and that the dose of adrenalin restored the balance and enabled the skin reaction to be completed.

Cataract.—Burge* finds that coagulation of the crystalline lens occurs with exposure to ultra-violet radiation, even with wave-lengths of 2,800 to 3,020 Å. This coagulation was made evident, as in the case of white of egg, only in the presence of a 1 per cent. calcium chloride solution. The cornea transmits waves as short as 2,970 to 3,020 Å. A section of lens 1 mm. thick absorbs all waves shorter than 3,130 Å. On the other hand, the aqueous (1 mm. thick) does not appreciably absorb the effective wave-lengths. Burge suggests that in glass-blower's cataract the ultra-

* *Medical Annual*, 1921, p. 93.

violet rays modify the lens protein in such a way that if abnormal amounts of calcium salts or silicate are present they combine to precipitate the protein, and so produce a coagulum in the lens, with resulting opacity.

In addition to glass-workers, cataract occurs in iron-smelters (Cridland), tin-plate workers (Healy), and chain-makers (Roberts).* It is very common in India, where very bright sunlight is experienced.

These observers blame *heat*, and suggest the use of goggles, but make no mention of the possibility of ultra-violet rays from the molten metals, etc., as being the true cause. This work of Burge is significant, and at any rate strongly suggests that operators of ultra-violet lamps, particularly the modern unhooded quartz mercury burner, should exercise great care in the protection of their eyes, lest in years to come " ultra-violet ray cataract " should claim its victims, as did X-ray dermatitis.

Chicken-Pox.—P. Gautier records two cases of severe varicella eruption on the shoulders which had been irritated by exposure to the sun.

A. Sack reports a case of a child, six and a half years old, where he thinks ultra-violet radiation treatment " sensitised the skin " and aggravated the eruption to an extraordinary degree.

A. Reiche refers to Sack's paper, and says that he had twenty children who developed chicken-pox while undergoing ultra-violet radiation treatment, and in none of these was the attack more severe. Our own experience (three cases) is that the eruption of chicken-pox is distinctly benefited by ultra-violet radiations, and that convalescence is hastened.

Menstruation.—It was observed that women patients subjected to ultra-violet irradiation during the menstrual period were apt to complain of increased languor and malaise, whereas previously they had experienced a tonic effect from the rays. Hill and Eidenow state that the bactericidal power of the blood is in many cases lowered during menstruation,

* *Medical Annual*, 1922, pp. 74, 75.

and that ultra-violet radiation treatment appeared to make this worse. It has been our practice to omit treatment for two days before the period and resume two days after, and women patients are warned to inform the nurse-in-charge at the clinic when the period is due.

Acute Infective and Pyrexial Cases.—In the same article these observers record that in rabbits injected with bacteria to produce a septicæmia the bactericidal power of the blood fell to a very low degree (10 per cent.). Radiation of the skin in such conditions did not increase the killing power of the blood.

Our own experience with patients who developed pyrexial disturbances during treatment bears out the view generally held that the treatment by irradiation of acute affections accompanied by pyrexia should be undertaken with great care.

These remarks apply particularly to pulmonary tuberculosis. About 1913 the writer treated a chronic appendicectomy scar and sinuses—duration one year—very successfully with sunlight. A nurse, encouraged by this result, took upon herself the responsibility of placing a boy of ten with active lung tubercle in a bright sun for some hours. The chest and back sustained a very acute solar dermatitis, the boy's temperature at once rose and remained high, and signs in the lungs were increased. He became very ill, developed acute tuberculous meningitis in a few days, and died.

CHAPTER IV

PRACTICAL USE OF THE QUARTZ MERCURY VAPOUR LAMP IN A MODERN PUBLIC HEALTH DEPARTMENT

(*a*) *Clinic, Staff, and Equipment.*—In September, 1924, the light clinic was inaugurated by the Smethwick Health Committee. Premises in the existing clinic for chest diseases were used, including a waiting-room, consulting-room, dressing cubicles, an office, and a treatment-room. The temperature of the latter can be maintained at 68° to 70° F. by means of a gas fire. A small revolving stool and chairs are provided.

At first two sessions were held weekly, on Monday and Friday afternoons, but the popularity of this clinic grew so rapidly and the benefit was so soon apparent that seven sessions were introduced, and as many as 124 patients were attended, some bi-weekly and some three times a week. Ante-natal mothers were given two sessions to themselves.

The staff consists of one medical officer and two nurses.

Description of Apparatus used.—The lamp used in the treatment of cases at the above clinic is known as the "K.B.B. Quartz Mercury Vapour Lamp." The assembly consists of the lamp and its stand, switch, a series resistance, and a voltmeter and ampere meter. This lamp works on a 220 to 250 volt direct current circuit, being connected to a 5-ampere plug with the resistance in series. Later a similar lamp, obtained as a spare burner, was suspended from the ceiling, so that for general baths a patient could sit between the lamps and have the back and front exposed simultaneously, thus halving the time of treatment taken with one lamp only.

Description of Lamp.—The burner consists essentially of a fused quartz U-tube, one limb of which is hermetically sealed.

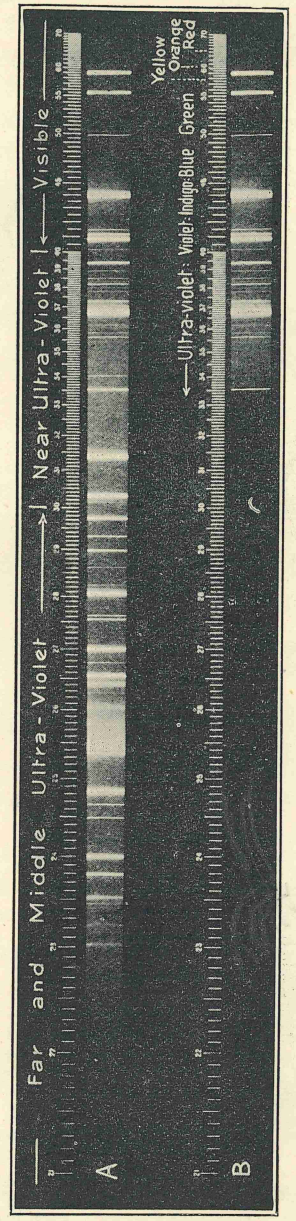


FIG. 4.

A. Spectrograph of atmospheric type K.B.B. quartz mercury vapour lamp.
B. Same spectrograph taken through ordinary window glass.

The other is closed by a stopper carrying a tungsten electrode. The whole tube is filled with mercury. The arc is started by a small branch tube sealed into the body of the quartz

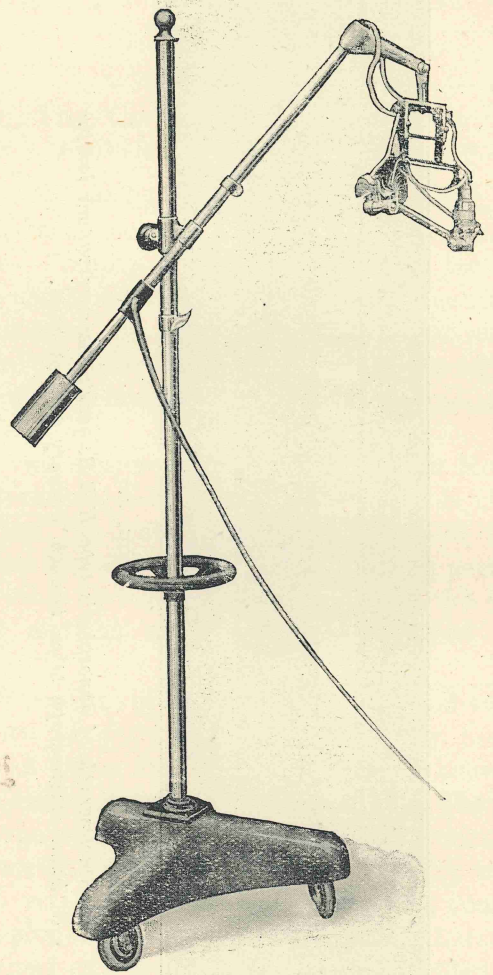


FIG. 5.—K.B.B. SUN LAMP WITH 440-VOLT BURNER, UNHOODED, WITH PORTABLE FLOOR STAND, TYPE "K."

Designed for Public Health Authorities and Infant Welfare Clinics.

burner and surrounded by a heating coil. When the circuit is closed by the switch the coil heats up, boils the mercury, and the arc is struck between the two liquid mercury faces.

The arc lengthens, the mercury travels up the open end of the U-tube, and remains at a constant level, determined by the construction of the arc tube. When this level is reached, the heating coil used for starting is automatically cut out. The lamp starts up at 4 to 5 amperes, and when the arc is struck settles down to burn at 2·5 amperes. The cost of running this lamp works out at about £4 10s. for 1,000 hours (current only power-meter).

Average Cost per Patient.—During the period from September, 1924, to December 31, 1925, 371 patients made 5,719 attendances, an average of 15·4 per patient. The average cost per patient works out at less than 3d. (at 1·7d. per

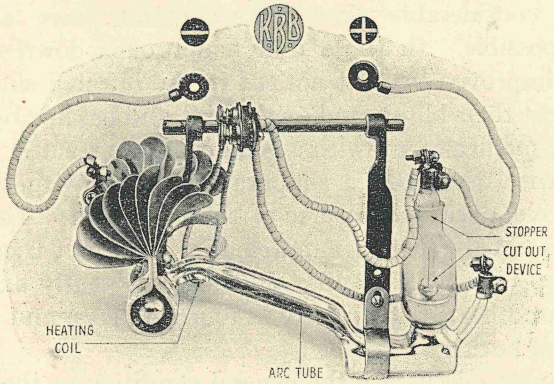


FIG. 6.—K.B.B. BURNER: 220-VOLT TYPE.

unit) for current only, but to this must be added about £20 per annum for additional heating, lighting, cleaning, etc., and about £10 for replacements of goggles, heating coils, cleaning of lamp, etc., making the average cost per patient 1s. 10d., or a little over one penny per attendance. These figures do not include proportion of salaries of medical officer and nurses.

(*b*) *Diseases Dealt With.*—It will be convenient to consider these under the various departments associated with the Public Health Service—namely, the Tuberculosis, Maternity and Child Welfare, and School Medical Departments. In addition to these, sundry other cases referred by local doctors came under our notice.

At the beginning of each section is given a table showing the number of cases dealt with and the progress made under treatment.

Tuberculosis Department

Eighty-three cases of tuberculosis came under treatment with ultra-violet radiation; of these, thirty-nine have been discharged and forty-four are still continuing treatment (see table on page 37).

Tuberculous Adenitis.—Hyperplastic forms yield rapidly to ultra-violet radiation, whereas the fibro-caseous types require long periods. Suppurating glands improve, but take a considerable time. These glands were aspirated where possible. In those that had broken down the first sign of improvement was noticed in the infected skin edges, which lost their bluish, unhealthy tint and became reddened, and in time healed up with a good cosmetic result.

One case developed a suppurating gland, with reddened skin above, during the course of the treatment. This gland was irradiated for five minutes at 1 foot, and then under the lamp was incised and 2 drachms pus gently expressed. The wound healed completely in fourteen days, and the skin remained healthy.

In almost every case the general condition of the patient improved definitely, and weight was gained. During the first two or three weeks of treatment the weight may fall slightly. One case of tubercle in axillary glands responded particularly well.

Case: F. R., Male, Thirty-three Years.—In June, 1924, injury to left thumb, followed by left axillary abscess. Several operations were done, the condition being regarded by the surgeon as tuberculous. X-ray treatment was tried at the hospital. He was referred to us on February 11, 1925, and then had a raw, unhealthy surface to left axilla, with tags of bluish indolent-looking skin surrounding it, together with a sinus leading from the outer end of the left clavicle to the axilla. In addition, he showed traces of a mild X-ray burn over his left shoulder and upper arm. He had been in bed for three and a half months, was miserable and thin, and very depressed. At first he was brought to the

TUBERCULOSIS DEPARTMENT.

Diseases.	*Total Cases commencing Treatment.*	*Treated and Discharged.*					*Continuing Treatment.*
		Total.	*Cured.*	*Improved.*	*In Statu Quo.*	*Worse.*	*Died.*	
Tuberculous adenitis	32	14	10	2	2	—	—	18
Lupus	19	6	5	1	—	—	—	13
Tuberculosis of bones and joints	5	5	1	3	1	—	—	—
Tuberculosis of lungs	16	10	—	4	2	—	4*	6
Tuberculosis of eye	5	1	—	1	—	—	—	4
Tuberculous peritonitis	3	1	—	—	1	—	—	2
Bazin's disease	1	1	1	—	—	—	—	—
Scrofuloderma	2	1	—	1	—	—	—	1
Totals	83	39	17	12	6	—	4	44

* 1 died cancer, 1 died in Romsley Hill Sanatorium, 1 received four doses only, 1 see note in text (p. 39).

clinic in a wheeled chair, and treatment commenced with a body-bath of two minutes at 3 feet back and front, and one minute at 2 feet to axilla. The exposures were gradually increased every second day to four minutes at 3 feet (bath), and three minutes at 1 foot to axilla. The X-ray burn rapidly cleared up, and he improved all round from the first week's treatment. By May 25, 1925, the axilla was healed with a good elastic scar, and he had gained 8½ pounds in weight. The most striking feature in his case was the change for the better in his general appearance and his increased cheerfulness. After the first fourteen days' treatment he walked to the clinic. The surgeon who saw him at the out-patients' department of the hospital found time to write and express his pleasure.

Total irradiation: 168 minutes.

Lupus.—In every case except one, improvement, continuous and marked, followed treatment. The resistant case was of the ulcerative moist type affecting the nose. The other ten cases were of the dry scaly type. Axel Reyn,* Sequeira, and numerous other observers, report satisfactory results in the treatment of this most intractable affection. With combined light-baths and local irradiation they claim 60 to 70 per cent. cures. One's own experience confirms this statement—viz., that general irradiation, combined with local irradiation, secures more effective and quicker results than local irradiation alone.

In the treatment of lupus by ultra-violet radiation the careful physician will not fail to keep a watchful eye upon the chest. It sometimes happens that the lupus patch will show remarkable improvement in a case when examination of the chest reveals active and progressive disease.

Bone and Joint Tubercle.—These included diseases of elbow, one; sternum and ribs, one; knee, two; and spine, one; and had all received treatment for considerable periods at the Orthopædic Hospital, except one (elbow). They were irradiated because, after returning to their homes, they had commenced to fall off in general health. They all improved, and the elbow case was cured with light treatment combined

* A. Reyn, *British Medical Journal*, September 22, 1923, p. 500.

FIG. 7.—February 18, 1925

FIG. 8.—December 19, 1925

LUPUS OF NOSE: CASE E. W.

To face page 38

FIG. 9.—June 20, 1925

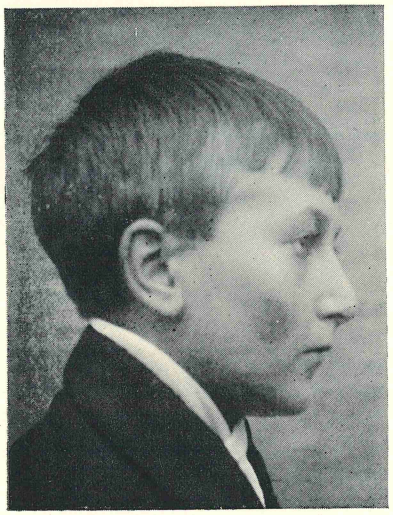


FIG. 10.—September 16, 1925

H. M., AGED 11 YEARS: COMMENCED TREATMENT, JANUARY 19, 1925; TOTAL IRRADIATION, 490 MINUTES

To face page 38

with splintage. A feature worthy of note in these cases is the improvement in the general bearing of the patients.

Lung Tubercle.—These included eight cases of active pulmonary tuberculosis with positive sputa, and eight cases of hilus tubercle. There were four deaths. It was soon evident that ultra-violet radiation is a powerful and possibly dangerous weapon in treating pulmonary tuberculosis. One man (W. B., aged thirty-six years) was found to be worse after his second treatment. Temperature rose to 101° F. the same evening, and he felt languid and ill. Enquiry revealed the fact that he was attending another doctor for irradiation, in the belief that he could not get too much of a good thing, and had informed neither of us of the fact. He continued to grow worse, and died four months later. In my opinion, ultra-violet treatment caused a " flare-up " in this case.

A second case (C. W., male, aged twenty-six years) had tubercle of both lobes of the lung, and infiltration of the right apex, with dysphagia. He developed glands in the neck the size of walnuts. Hearing of improvement in other cases of adenitis, he came asking for light treatment. He was advised against it, but persisted in coming. He had local treatment to neck glands only on six occasions. He promptly lost weight, and his condition seemed worse. He was sent to hospital, and died six weeks later.

The third case who died had profound anæmia, for which he was given light-baths. He felt brighter, but the anæmia was uninfluenced. Cause of death, which occurred two months later, was carcinoma of liver.

The fourth case was transferred to a sanatorium after only four treatments, and had gained weight. He died later in the sanatorium.

Of the other T.B. + cases, two gained weight and improved and one was worse.

Of the hilus cases, four showed definite improvement, two did not, and one developed hysteria and was sent to hospital.

In attempting to treat any case of active lung tubercle the writer would advise great caution. Dosage should

commence with short daily exposure of arms at first, then arms and legs, later thighs, and after two or three weeks' "preparation" in this way, short baths to whole body, gradually increasing according to reaction of patient.

In none of the above cases was an increased tendency to hæmoptysis observed, but the slightest overdose of light was followed by marked depression, and sometimes increase of cough, sweats, and loss of appetite.

Possibly further experience will show improved results in cases of pulmonary tubercle, particularly in "early" cases, but the writer soon found that results in other branches of the work were so encouraging that the case of pulmonary tubercle was not urged to attend the clinic.

Tuberculous Peritonitis—*Mrs. N., Aged Twenty-seven Years.*—June 26, 1924: In hospital for currettage; had diarrhœa, constipation, vomiting, and debility.

Nov. 25, 1924: In hospital again, and had a tuberculous appendix and ovarian cyst removed; surgeon found tuberculous peritonitis.

Jan. 7, 1925: Referred to Smethwick Chest Clinic; no signs in chest; no chest symptoms; anæmic, weak; no appetite; abdominal pain at times; abdomen slightly tumid; no masses felt.

Ultra-violet radiation to abdomen to July 19, 1925.

Total irradiation: 368 minutes.

By this time she had gained 6 pounds, and looked and felt better. She had a relapse, with pain in left iliac fossa, constipation, and menorrhagia, and lost 10 pounds.

Sept. 9, 1925: Has resumed treatment, and is again improving. Average dose, five minutes at 2 feet to abdomen.

Tuberculosis of Eye, Bazin's Disease, and Scrofuloderma.—Five of these cases are still under treatment, and show considerable improvement.

One of the eye cases (tuberculous iritis) was at first very sensitive to light.

Maternity and Child Welfare Department

Of the 165 cases reviewed, forty-seven were expectant mothers referred from the ante-natal clinic for light treatment. The word "debility" is used, perhaps unwisely, on

MATERNITY AND CHILD WELFARE DEPARTMENT.

Diseases.	Total Cases commencing Treatment.	Treated and Discharged.						Continuing Treatment.
		Total.	Cured.	Improved.	In Statu Quo.	Worse.	Died.	
Ante-Natal Mothers:								
Debility	30	16	2	10	4	—	—	14
Insomnia	4	2	1	1	—	—	—	2
Anæmia	13	7	—	3	4	—	—	6
Totals	47	25	3	14	8	—	—	22
Babies and Toddlers:								
Marasmus	5	2	1	1	—	—	—	3
Rickets	49	21	14	7	—	—	—	28
Delayed dentition ..	8	3	2	—	—	—	1*	5
Not thriving	40	14	5	9	—	—	—	26
Bronchitis	9	2	—	2	—	—	—	7
Peritonitis	2	2	1	—	—	—	1	—
Whooping-cough ..	3	3	3	—	—	—	—	—
Skin diseases ..	2	—	—	—	—	—	—	2
Totals	118	47	26	19	—	—	2	71

* Child feeble-minded; died of broncho-pneumonia.

the record cards, and as usual covers a multitude of symptoms. In these cases it signified lack of energy, appetite, and feelings of depression and low spirits in the expectant mother, sometimes accompanied by restlessness at night. Cases presenting definite insomnia are classified as such, as are cases of anæmia. Strangely enough, some little difficulty was experienced at first in getting these ante-natal mothers to attend for irradiation, but by persuasion and taking care to keep well within the limits of a mild erythema dose, this diffidence was soon overcome, and now the clinic is growing popular. Only twenty-two cases are shown as "continuing treatment," but many more have recently commenced to attend, but have not attended long enough to be included in the figures.

This light clinic for expectant mothers has been available for a short period only, so that one has not enough experience to make emphatic statements. At the same time, the growing popularity of the clinic and the appearance, improved cheerfulness, increased appetite, and better mental outlook obtained even after the first three or four treatments gives encouragement. Two of the mothers have since had fine babies, and are breast-feeding them.

A striking result was the attainment of normal sleep soon after the treatment commenced.

Several of the cases returned as *in statu quo* ceased attending after only four treatments—*i.e.*, two weeks. From what we know of the power of ultra-violet radiation to raise the bactericidal power of the blood and from a possible influence in aiding lactation, it seems well worth while to irradiate the expectant mother who is "below par," or where home conditions deprive her of sufficient air and exercise.

Babies and Toddlers.—The table shows that 118 were irradiated, the average period in the "treated and discharged" series working out at 150 minutes' total irradiation. At this clinic the babies attend three times a week. The mother holds the infant at 4 feet from the lamp in the first instance for two minutes for the back and two minutes for the front of the body. This is increased by a minute per week up

to five or six minutes. Children who appear to stand the light well are then brought to 3 feet from the lamp. As a rule, with this dosage little or no erythema is seen. Sometimes after four or five baths there is a slight transient erythema in some babies, and then on succeeding occasions no erythema.

The babies' eyes are protected by a bandage, and the mothers and toddlers wear goggles. Many of the mothers expose their chests and arms to the light, and volunteer the information that they feel more cheerful and more energetic since bringing the baby to the light clinic.

It is difficult to restrain one's enthusiasm in writing about the effects of ultra-violet radiation in these babies and toddlers. Taking the milder abnormalities first, children suffering from malnutrition, simple gastric disturbances, fretfulness, nervous irritability, inadequate increase of weight for no definite reason, babies who do not seem to thrive—who "hang fire," as it were—respond at once, and show most marked improvement. After the first three or four treatments the babies show a very definite increase of capacity for movement; movements are more vigorous, the babies are obviously brighter, more alert, and more contented. The mothers report better nights and quieter sleep. Occasionally a "light-sensitive" child is met with, where even the mild dosage of ultra-violet radiation outlined above is followed by loss of appetite, fretfulness, and nervous irritability, sometimes accompanied by sleeplessness. These cases are moved 6 feet or more from the lamp, kept at the two-minute dose, and brought gradually nearer at each sitting. All have responded to this method.

It would appear that very brief exposures are quite sufficient to produce satisfactory results in babies and young children.

Rickets.—Of the forty-nine cases treated, twenty-one were discharged showing progressive improvement all round. In my opinion, ultra-violet radiation is as specific in the cure of rickets as is cod-liver oil, and acts in a much shorter time. I am of opinion that ultra-violet radiation should be applied to every child in our industrial towns, especially during the

winter months, and preferably in the first eight weeks of life, as a prophylactic against rickets and spasmophilia.

Several babies were referred for treatment with evidence of slight rickets only, but with *delayed dentition*. These cases responded well, and soon after treatment the teeth erupted rapidly and satisfactorily.

Illustrative Cases—*T. L., Male, Sixteen Months.*—Breast-fed to present time; illiterate mother; large head; open fontanelle; bronchitis; unable to walk; six teeth.

Nov. 19, 1924: Ultra-violet radiation commenced. Weight, 14 pounds 9 ounces.

Dec. 1, 1924: Child livelier and stronger; less fretful; X rays showed florid rickets.

Dec. 22, 1924: Sleeps well now; sweats less; cries less. Weight, 15 pounds 4 ounces.

Jan. 14, 1925: Improvement continued. Weight, 16 pounds 8 ounces.

Jan. 19, 1925: Slight bronchitis. Weight, 16 pounds 2 ounces.

Feb. 18, 1925: Still slight cough, but improving; X ray showed increased calcium deposit. Weight, 17 pounds 4 ounces.

March 18, 1925: Child very well and very active; X ray showed dense calcium deposit. Weight, 17 pounds 14 ounces.

April 14, 1925: Child quite well. Weight, 18 pounds 7 ounces.

May 15, 1925: Child quite well. Weight, 20 pounds.

Total irradiation: 130 minutes.

B. S., Male, Seven Months.—Mother tuberculous; bottle-fed; slight rickets; no increase in weight for six weeks; bronchitis; no teeth.

Feb. 18, 1925: Ultra-violet radiation commenced. Weight, 16 pounds 12 ounces.

March 4, 1925: Improving; no teeth. Weight, 17 pounds.

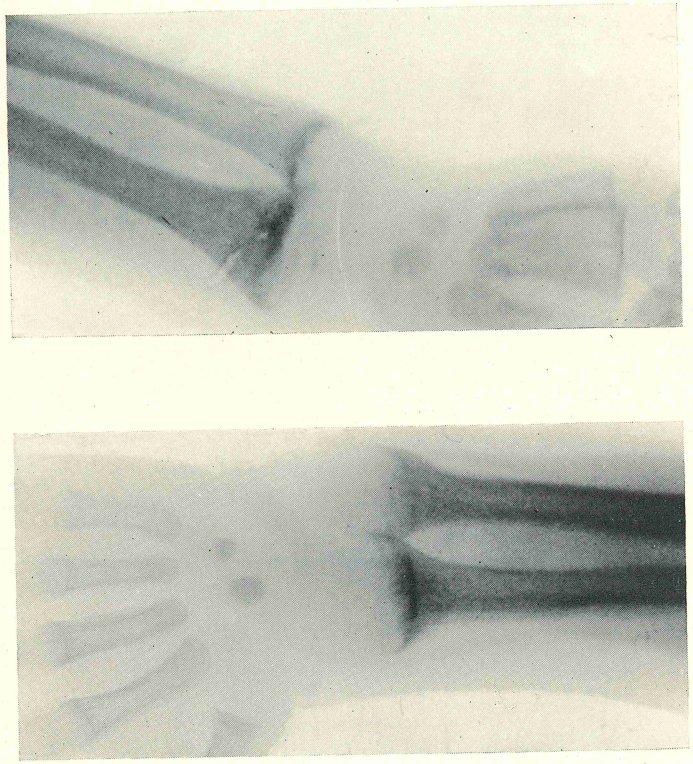
March 16, 1925: Cut two teeth; sleeps better; better colour. Weight, 17 pounds 11 ounces.

April 17, 1925: Child improving all round; three teeth. Weight, 18 pounds 6 ounces.

April 29, 1925: Six teeth. Weight, 19 pounds 12 ounces.

May 18, 1925: Seven teeth. Weight, 21 pounds 8 ounces.

July 12, 1925: Child developed whooping-cough; lost 2 pounds; two-hourly spasms day, and oftener night; ultra-violet radiation continued, and after second week of the disease no whoop or vomiting occurred.



November 16, 1925: After 106 minutes' irradiation. X ray shows scallop line of new bone in the epiphyseal aspect of diaphysis with increased deposition of calcium.

November 28, 1924: X ray after three treatments. Sixteen minutes' irradiation. Ends of diaphysis are scalloped. Epiphyses are broadened and show osteoid tissue with a few isolated trabeculæ of calcified bone. Dark line across the diaphyseal aspect of epiphysis of radius represents commencing deposit of calcium due to treatment. Shafts show rarefaction.

FIG. 11.—ACUTE RICKETS: T. L., 16 MONTHS

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FIG. 12.—CASE T. L.

March 18, 1925: After 230 minutes' irradiation. X ray shows continued healing. The shafts of the bones are denser and a line of increased calcium deposit shows well in the subperiosteal bone. The epiphyses are well outlined and the deposit of calcium denser, and the edges show more clearly.

April 6, 1925: After 274 minutes' irradiation. Shafts denser, outline of epiphyses well defined. Child clinically cured.

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FIG. 13.—HEALING RICKETS: R. C., MALE, 1 YEAR 5 MONTHS

May 28, 1925: After 175 minutes' irradiation. New bone is dense and forms an almost straight line.

January 28, 1925: This shows evidence of healing rickets of fairly short duration. The epiphyseal border of diaphysis is almost straight and no scalloping has occurred.

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Sept. 2, 1925: Child firm and strong and lively; no sign of bronchitis. Weight, 23 pounds 6 ounces.

Total irradiation: 478 minutes.

B. M., Female, Fifteen Months.—Rickets; wide, soft fontanelle; poor appetite; restless at night; fretful; two teeth.

July 3, 1925: Ultra-violet radiation commenced. Weight, 19 pounds 2 ounces.

July 12, 1925: Appetite better. Weight, 20 pounds.

July 27, 1925: Fretful; gums sore; teething. Weight, 19 pounds 2 ounces.

Aug. 10, 1925: Sleeps better; five teeth. Weight, 20 pounds $\frac{1}{4}$ ounce.

Aug. 28, 1925: Six teeth. Weight, 20 pounds 7 ounces.

Sept. 14, 1925: Child very well and active. Weight, 20 pounds 13 ounces.

Total irradiation: 166 minutes.

B. V., Male, Nine Months.—Rickets; bottle-fed; fat and rather flabby; open fontanelle; no teeth.

Jan. 31, 1925: Ultra-violet radiation commenced. Weight, 16 pounds $5\frac{1}{2}$ ounces.

Feb. 9, 1925: Vomiting feeds. Weight, 16 pounds $6\frac{1}{2}$ ounces.

Feb. 20, 1925: Appetite better, keeps down feeds; slight cough. Weight, 16 pounds 4 ounces.

Feb. 27, 1925: Child much firmer and healthier looking; has now twelve teeth. Weight, 16 pounds 4 ounces.

Total irradiation: 48 minutes.

Whooping-Cough. — Whooping-cough developed in the case of three infants while undergoing irradiation treatment. The treatment was continued, and in these cases the writer felt that the disease ran a milder and much shorter course, the spasms ceasing at the end of two weeks. Dr. Ferdinand Schott,* of Cassel, gives details of ten cases of whooping-cough treated with ultra-violet radiation. In practically every case the spasms and vomiting ceased after three to five irradiations given at intervals of two days and doses of three to five minutes back and front. Success was obtained in every case. In three of the cases where the general health of the children was poor, the radiations were continued until ten to fifteen had been given, when the patient's general condition was markedly improved and resulted in complete recovery.

* F. Schott, *Deutschen Medizinischen Wochenschrift*, No. 35, 1923.

Action of Ultra-Violet Radiation in Rickets.—It may be stated quite definitely that ultra-violet radiation prevents rickets in babies, and will produce successful cures in the same way that cod-liver oil will prevent and cure this disease. In connection with this prevention of rickets most valuable work has been done quite recently, and efforts have been made to ascertain what common element is present in the action of cod-liver oil and ultra-violet radiation. Kuegelmass and McQuarrie* stated that cod-liver oil and other antirachitic factors, when oxidised, gave off ultra-violet radiations. This was not accepted, and was disproved by the experiments of Schultz and Morse as a preliminary to their investigations of the spectroscopic properties of cod-liver oil. That the antirachitic factor was due to vitamin A in cod-liver oil was believed for some time, but McCollom, Simmonds, Becker, and Shipley showed that in cod-liver oil heated to 100° C. and aerated with bubbles of air the vitamin A was sterilised, and yet the oil was still effective in preventing rickets.

In 1921 Wacker and Beck pointed out that cholesterol played a significant part in the antirachitic power of cod-liver oil. Zucker found that the active substance in cod-liver oil was in the ether-soluble non-saponifiable fraction of the oil.

Turning to the antirachitic properties of ultra-violet radiations, Hess found that the most active ultra-violet wave-lengths for preventing rickets lay from 3,000 to 3,130 Å. In a series of recent experiments, Hess, Weinstock, Steenbock, and Kramer have reported remarkable results, in which they showed that antirachitic properties can be imparted to various previously inert fluids by ultra-violet radiation. These substances included cotton-seed oil, linseed oil, and chemical substances, such as cholesterol and phytosterol. Kramer fed eight cases of rickets in infants with milk irradiated at 2 feet from the lamp, and concluded that healing was produced in every case.

Cholesterol is widely spread through the animal body, and may be prepared from brain substance.

* Kuegelmass and McQuarrie, *Science*, 1924, vol. lx., p. 372.

Phytosterol is a main constituent of the non-saponifiable fraction of vegetable oils, such as cotton-seed oil.

Amongst other inert substances becoming antirachitic after irradiation, lard, mussels, dried milk, liver, and lettuce leaves may be mentioned.

An interesting point emerges here—namely, that over-irradiation causes both cholesterol and phytosterol to lose their antirachitic properties, gained by a suitable dose of ultra-violet radiation. In both cases the antirachitic properties seem to be retained for long periods, once gained, especially in the presence of a vegetable or linseed oil.

Hess, Weinstock, and Helman suggest the following hypothesis to explain the protection from rickets by sunlight or ultra-violet radiation: The epidermis of the skin is plentifully supplied with cholesterol; solar rays and ultra-violet radiations "activate" this cholesterol, and render it antirachitic; this activated cholesterol is transported by the circulation throughout the body. Rats on a rachitic diet were fed with irradiated skin, and did not develop rickets; whereas control rats fed on non-irradiated skin did develop rickets.

With regard to the ante-natal prevention of rickets, the idea has been prevalent that attention to diet enables the mother to store up sufficient antirachitic substances which will prevent rickets in the offspring.

Korenchevsky, in his work on rats, rather supported this view; but Hess and Weinstock, in an elaborate enquiry into this subject, concluded that rickets cannot be prevented by improving the diet of the mother (1) previous to pregnancy, (2) during pregnancy, or (3) throughout lactation, although it can be mitigated to a certain degree.

Further, infants could not be protected by giving the mother cod-liver oil during the last two months of pregnancy, as the active principle of cod-liver oil is not excreted in the mother's milk.

It would seem from the above, therefore, that rickets is mainly of post-natal origin, and our efforts for prevention must be directed mainly to this period.

The logical plan in our large cities and industrial centres

would be to provide facilities for ultra-violet radiation at each infant welfare centre, and endeavour to irradiate every infant for a short period—say, within the first eight weeks of life.

Dr. Palm, in the *Practitioner* as long ago as October, 1890, suggested " the systematic use of sun-baths as a preventive and therapeutic measure in rickets and other diseases." With modern conditions of life in towns and crowded urban areas, we are more than ever in need of sunlight; recent research has proved Palm to be right, and the modern quartz mercury vapour lamp provides the means by which such preventive measures could be easily, cheaply, and successfully carried out.

In the case of female children, preventive irradiation would be productive of remote as well as immediate beneficial results, and would help materially in years to come to reduce the mortality in child-birth by a not inconsiderable extent. In support of this view, which at first sight may seem a little far-fetched, one may refer to the measurements made by H. P. Ashby* in 150 normal children and 150 rickety children:

Averages.	*At Age Five Years.*	*At Age Thirteen Years.*
External conjugate in normal children	4·8 inches	6·0 inches
External conjugate in rickety children	4·2 ,,	4·9 ,,

He concludes that rickets in early childhood allowed to continue is the cause of the rickety flat pelvis of the adult woman.

School Medical Department

It will be seen from the table that 103 cases came under treatment. These cases were referred to chiefly from the school clinics or from routine school medical inspection.

Debility.—Satisfactory results were obtained in debilitated children who seemed unable to put on weight, or who seemed retarded in growth. Perhaps the most marked effect of the

* H. F. Ashby, *British Medical Journal*, February, 1922, p. 906.

SCHOOL MEDICAL DEPARTMENT.

Diseases.	*Total Cases commencing Treatment.*	*Treated and Discharged.*						*Continuing Treatment.*
		Total.	*Cured.*	*Improved.*	*In Statu Quo.*	*Worse.*	*Died.*	
Debility	29	12	6	4	2	—	—	17
Catarrh and bronchitis	12	6	4	2	—	—	—	6
Unresolved pneumonia	4	3	3	—	—	—	—	1
Alopecia	11	2	2	—	—	—	—	9
Chorea	20	9	7	—	2*	—	—	11
Rheumatic carditis ..	4	1	—	—	1	—	—	3
Rheumatic nodes ..	1	1	1	—	—	—	—	—
Osteomyelitis	1	1	—	1	—	—	—	—
Psoriasis	3	—	—	—	—	—	—	3
Impetigo	3	3	3	—	—	—	—	—
Septic sores	9	5	5	—	—	—	—	4
Eczema	6	—	—	—	—	—	—	6
Totals	103	43	31	7	5	—	—	60

* Both children mentally defective.

ultra-violet radiation in these children was the increase in height noticed, and to a lesser extent the increase in weight. Weight sometimes fell during the first two weeks of treatment, and then steadily increased. There was also evidence of increased brightness in these children.

Skin Diseases.—In the common skin diseases of school life rapid improvement was noticed, particularly in the child subject to impetigo, septic little sores, etc. Several children had ringworm of the body during treatment. Usually two local irradiations cured this condition.

Chorea.—Twenty cases of chorea were treated, and the results obtained were rapid, surprising, and lasting. If these results can be obtained consistently in a large number of cases, a great saving will accrue to school attendance, for these cases are often out of school for many months at a time. The cases returned as *in statu quo* were mentally defective.

Illustrative Cases—*A. S., Female, Ten Years.*—Very nervous child; afraid to cross road by herself; twitching movements of right arm and leg; enlarged unhealthy tonsils; heart sounds normal; indolent blue scars in neck after operation for adenitis in 1923.

Oct. 20, 1924: Ultra-violet radiation commenced; three minutes at 3 feet body. Height, 4 feet 3 inches; weight, 4 stone 2¾ pounds. Irradiation continued bi-weekly.

Nov. 24, 1924: General condition improving; chorea cured.

Dec. 25, 1924: Child no longer nervous; more robust. Weight, 4 stone 4¾ pounds.

Feb. 9, 1925: Discharged; scars in neck healthy; marked improvement in appearance and bearing; no sign of chorea; not nervous now. Height, 4 feet 5 inches; weight, 4 stone 7 pounds; gained 4¼ pounds and grew 2 inches.

Total irradiation: 252 minutes.

M. B., Female, Aged Eight Years.—Marked twitching of right shoulder and head; rolls eyes; abdominal pains; very nervous child; drops things; tonsils ragged; heart normal; duration, six months.

July 24, 1925: Ultra-violet radiation commenced; three minutes at 3 feet bi-weekly. Height, 4 feet; weight, 3 stone 8¾ pounds.

Aug. 16, 1925: More co-ordination and self-control. Weight, 3 stone 8 pounds.

Aug. 28, 1925: No signs of chorea now.

Sept. 16, 1925: Discharged; child quite well. Height, 4 feet ¾ inch; weight, 3 stone 7¾ pounds.

Total irradiation: 114 minutes.

Bronchitis and Post-Pneumonic Conditions.—Certain of these children keep absenting themselves from school, and, despite drugs and emulsions from their doctors, do not seem to make any progress. Ultra-violet radiation treatment in the small number dealt with produced very definite improvement in most cases.

I. M., Female, Aged Five Years and Eleven Months.—History of recurrent "colds" and three attacks of "bronchopneumonia"; last attack left side November, 1924; diminished expansion left side and numerous sibilant rhonchi; off school four months.

Dec. 9, 1924: Ultra-violet radiation commenced; three minutes at 3 feet. Height, 3 feet 9 inches; weight, 3 stone 2¾ pounds.

Dec. 31, 1924: Improved; cough less; more energy. Weight, 3 stone 5 pounds.

Jan. 21, 1925: Returned to school. Weight, 3 stone 5¾ pounds.

Feb. 24, 1925: Cough almost ceased; livelier; appetite better. Weight, 3 stone 7¼ pounds.

March 2, 1925: Slight relapse; off school for fourteen days. Weight, 3 stone 5¼ pounds.

April 1, 1925: Improvement renewed and continued. Weight, 3 stone 6½ pounds.

May 4, 1925: Improvement continued, and so on to May 18, 1925: six minutes at 3 feet back and front. Weight, 3 stone 7½ pounds.

June 22, 1925: Discharged; very well; no symptoms; chest expansion equal both sides now; no signs in lung; whole appearance healthier, and child noticeably brighter and more lively. Height, 3 feet 9¼ inches; gained 5 pounds in weight and ¼ inch in height.

Total irradiation: 348 minutes.

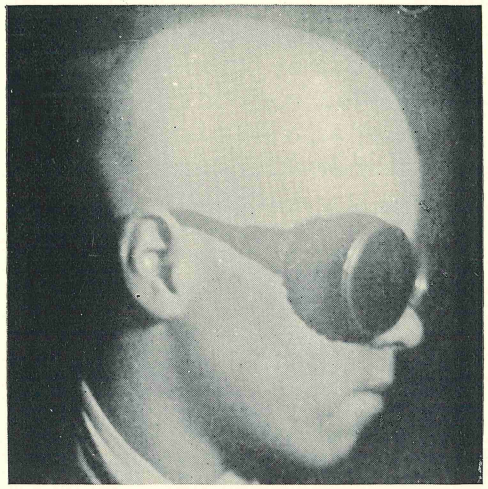
Alopecia.—These cases are very distressing in school children, and involve the child in much ridicule from its school-fellows, especially where the loss of hair is complete, even to eyebrows and eyelashes. Moreover, when one attempts to treat the more severe cases, all sorts of efforts are rewarded with little or no result.

Now ultra-violet radiation certainly stimulates the growth of certain hairs. When the male operator first starts using ultra-violet radiation, he finds that his beard grows most uncommonly rapidly on those days on which he manipulates the lamp, and next morning his razor is called upon to deal with a more than usually resistant stubble. This fact is obvious to the most casual observer. Smarting of the face is also present at first, but this wears off after a time. The stimulation of the beard persists, however.

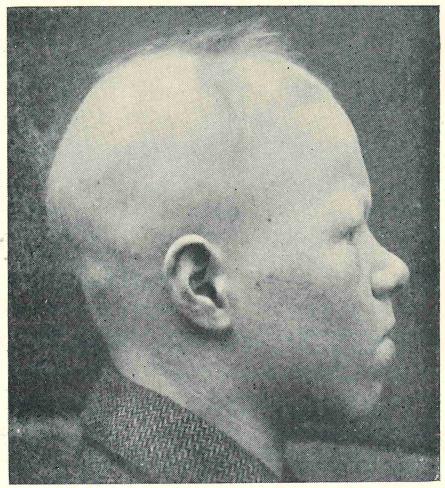
The course of alopecia areata is so capricious that it is difficult to judge the real value of any treatment. Results appear to bear some relation to the duration of the alopecia. At any rate, in a recent alopecia hair is likely to appear more quickly than in a case of longer duration.

In endeavouring to restore vigour to the scalp, we try to improve the blood supply by friction, massage, stimulating lotions, etc. With ultra-violet radiation we may safely and repeatedly produce an intense erythema far ahead of any similar effect obtained by heat or drugs. In treating alopecia a sharp erythema of the third degree, repeated once a week or in ten days, seems to produce the best results. The burner is placed 6 to 8 inches from the bald patch, and exposures of from ten to twenty minutes are given. Greasy scalps stand very long exposures without undue reaction. The aim is to produce an intense hyperæmia, and to stop short of blistering. At first it is noticed that the hair stops falling so fast, and then falls not at all. For a time, possibly weeks, nothing further is seen, and then fine downy hairs begin to show. Examined under the microscope, these hairs are seen to be about one-tenth part of the diameter of a normal hair, and have pointed ends—that is to say, they are new hairs. Often the first sparse crop, and possibly even a second crop, falls out, and finally the hair grows definitely.

Eleven cases in all have been treated in school children—six girls and two boys with alopecia areata, and two boys and one girl with complete baldness. Of these eleven cases two are cured, five show definite improvement, and four are still *in statu quo*.



November 10, 1924



August 24, 1925: Still under treatment

FIG. 14.—COMPLETE ALOPECIA: G. C., AGED 12 YEARS

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Illustrative Cases—*E. E., Female, Five Years.*—Alopecia areata; falling of hair commenced four weeks ago; large bare patch from crown to occiput; hair thin and still falling; cause unknown.

Jan. 6, 1925: Ultra-violet radiation commenced. Weight, 2 stone 11¼ pounds.

Jan. 19, 1925: Hair stopped falling; no new hairs on patch.

Feb. 16, 1925: Child as before; ceased to attend. Weight, 2 stone 12¾ pounds.

Sept. 19, 1925: Visited; nurse reports that hair grew four weeks after last visit, and scalp now covered with a profuse growth.

M. S., Female, Aged Nine Years and Six Months.—Complete idiopathic alopecia; splendid hair till February, 1922, when it commenced to fall out; at first round occiput and then all over; by March, 1922, she was completely bald; no eyebrows; no eyelashes.

Sept. 3, 1924: Ultra-violet radiation commenced. Height, 3 feet 10 inches; weight, 3 stone 5¾ pounds.

Jan 12, 1925: Eyebrows growing; no sign of hair on head.

Feb. 6, 1925: Eyebrows and eyelashes growing well; no sign of hair on head.

July 6, 1925: A few fine hairs on scalp over crown.

Aug. 10, 1925: Thin crop fell out.

Sept. 16, 1925: Normal eyebrows and lashes; no sign of further hair on scalp. Height, 4 feet ½ inch; weight, 3 stone 8¾ pounds.

April 19, 1926: No sign of further hair on scalp; treatment continuing. Height, 4 feet 1 inch; weight, 3 stone 12¼ pounds.

G. C., Male, Twelve Years.—Complete idiopathic alopecia; boy as bald as an egg; no eyebrows; no eyelashes; lost all his hair at seven years of age.

Sept. 29, 1924: Ultra-violet radiation commenced weekly; scalp and occasionally general bath. Height, 4 feet 7½ inches; weight, 5 stone 2 pounds.

Nov. 10, 1924: Fine sparse hairs on scalp; very fair in appearance.

Jan. 5, 1925: These fell out.

March 2, 1925: New crop of fine hairs on scalp; eyebrows and eyelashes show slight irregular growth.

June 15, 1925: Fine hairs more numerous; a few long, fine hairs on scalp.

Aug. 24, 1925: Scalp covered all over with fine hair ¼ inch long; eyebrows and eyelashes growing well and evenly. Height, 4 feet 11 inches; weight, 5 stone 12 pounds.

April 21, 1926: Treatment continuing with progress. Height, 4 feet 12 inches; weight, 6 stone 7 pounds.

F. J., Male, Aged Nine Years.—Complete alopecia; had ringworm of scalp at seven years of age; no X-ray treatment, but hair all fell out; no eyebrows; no eyelashes.

April 27, 1925: Ultra-violet radiation commenced. Height, 3 feet 11 inches; weight, 4 stone.

May 4, 1925: No effect seen till this week, when eyelashes appeared on right eyelids; no hair on head.

May 11, 1925: Pause due to measles.

June 16, 1925: Eyelashes and eyebrows growing well on both sides; a few fine hairs at sides of scalp appearing.

Sept. 16, 1925: Eyebrows and eyelashes very satisfactory; a few fine hairs on scalp still present and growing. Height, 4 feet $\frac{3}{4}$ inch; weight, 4 stone $2\frac{1}{2}$ pounds.

April 19, 1926: Fine hairs appear on scalp, but drop out; progress evident, but slow. Height, 4 feet $1\frac{1}{4}$ inches; weight, 4 stone 9 pounds.

I. C., Female, Aged Nine Years.—Alopecia areata (severe); hair began to fall at the age of four to six months; numerous large bare patches now; hair thin and falling very markedly; no eyebrows; no eyelashes; cause not known.

Jan. 26, 1925: Ultra-violet radiation commenced. Height, 4 feet $3\frac{1}{2}$ inches; weight, 4 stone $8\frac{1}{2}$ pounds.

Feb. 23, 1925: Hair falling out less.

May 6, 1926: Hair ceased falling out; no new hair yet.

Aug. 10, 1925: Eyebrows started to grow.

Sept. 16, 1925: No hair on bare patches; no further falling; eyebrows growing strongly. Height, 4 feet 5 inches; weight, 5 stone $1\frac{3}{4}$ pounds.

Feb. 5, 1926: Fine hairs on bare patches; no further falling; eyebrows and lashes grown; left district.

If brushings and combings are collected and weighed on a chemical balance weekly, the cessation of falling process under ultra-violet radiation treatment can be readily demonstrated. It will be noticed that a decrease in amount lost occurs after washing, probably due to mechanical loss of hair during the washing process, which hair is not collected.

Illustrative Case—*Miss K., Aged Thirty-two.*—

1st week	..	0·76 grm.	
2nd ,,	..	0·45 ,,	
3rd ,,	..	0·64 ,,	(wash)
4th ,,	..	0·24 ,,	
5th ,,	..	0·65 ,,	
6th ,,	..	0·60 ,,	
7th week	..	0·65 grm.	(wash)
8th ,,	..	0·27 ,,	
9th ,,	..	0·45 ,,	
10th ,,	..	0·58 ,,	
11th ,,	..	0·35 ,,	
12th ,,	..	0·25 ,,	

and remained at 0·25 grm. on average.

CHAPTER V

VITAGLASS

THE writer would like here to call attention to one other possibility in connection with the utilisation of ultra-violet rays of solar origin, which may have a far-reaching effect in school medical work.

Ordinary glass, as we have seen, cuts out ultra-violet radiations almost completely—at any rate, waves shorter than 3,000 Å. do not pass, although the room may appear to be flooded with sunshine. Rays below 3,100 Å. appear to be the " Vital Rays "—valuable rays intimately associated with metabolism and growth.

Our school children are shut indoors for many hours a day within brick walls in class-rooms with ordinary glass windows which effectively rob them of even the relatively small amount of ultra-violet rays available in winter or summer in our smoke-enshrouded cities and towns.

Mr. F. E. Lamplough, of King's Norton, Birmingham, has invented a glass which he calls " Vitaglass," and which is manufactured by Messrs. Chance Bros. and Co., Ltd., of Smethwick. Reference to the spectrograph below will show that this glass allows to pass ultra-violet rays down to 2,750 Å. The source of ultra-violet radiation here is the iron arc, and the spectrum of this arc (*a*) is compared with (*b*) screen of " Vitaglass " and (*c*) ordinary window glass.

This glass will be most useful in schools, hospitals (particularly children's hospitals), nurseries, sanatoria, verandahs, tungsten filament lamps, etc.

In June, 1925, the writer persuaded the Smethwick Education Committee to instal this glass in a class-room in one of the local schools. Boys of nine to eleven years were taken, and arrangements were made to keep thirty boys in this class-room for twelve months. A control group of boys occupied an adjoining class-room with a similar aspect.

The heights and weights of these two groups were taken, together with hæmoglobin estimations, and these observations were repeated at the end of nine months.

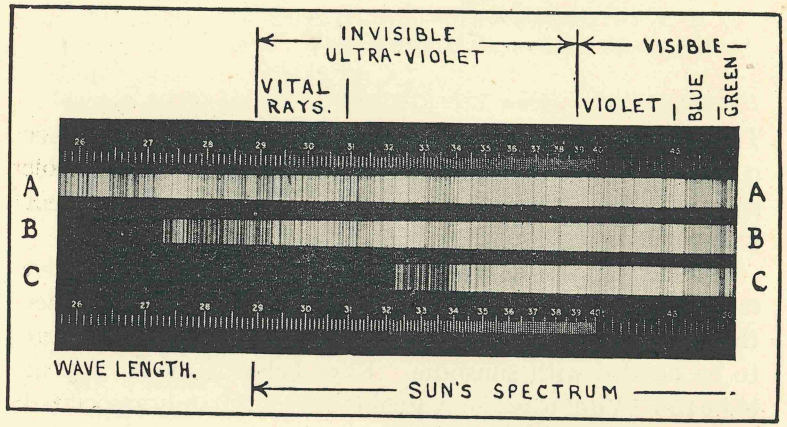

FIG. 15.—*Spectrum photograph, illustrating the composition of light from an electric arc between iron poles, taken by the Hilger Quartz Spectrograph, with wave-length scale.*

A. Light of iron arc, without screen.
B. Light of iron arc passed through Vitaglass 2 mm. thick.
C. Light of iron arc passed through ordinary glass 2 mm. thick.

"B" shows that Vitaglass transmits the vital rays to the extreme limit (wave-length 290) of the sun's spectrum.

"C" shows that the vital rays are completely obstructed by ordinary window glass.

The results in such a small series are obviously open to much criticism, but seem definitely encouraging, and are here offered for what they are worth.

	June 1, 1925.	*March* 31, 1926.	*Average Gain.*
Control Class:			
Average weight ..	60·04 pounds	62·87 pounds	2·83 pounds
Average height ..	51·78 inches	53·30 inches	1·22 inches
Average hæmoglobin (per cent.) ..	76·58	84·11	7·53
Vitaglass Class:			
Average weight ..	67·90 pounds	74·01 pounds	6·11 pounds
Average height ..	54·06 inches	55·92 inches	1·86 inches
Average hæmoglobin (per cent.) ..	77·90	94·04	16·14

Note.—Von Fleischel's hæmoglobinometer was used.

The class master worked out the loss of attendance in each class for the three months preceding the test, and for the nine months of the test, and gives the following results:

Period.	*April to June* 29, 1925.	*June* 30 *to July,* 1925.	*August* 24 *to December* 22, 1925.	*January* 11 *to March* 29, 1926.
Control Class: Percentage of absences ..	8·43	5·93	8·43	6·65
Decrease in percentage of absences: 1·78				
Vitaglass Class: Percentage of absences ..	12·78	11·17	7·93	7·27
Decrease in percentage of absences: 5·51				

CHAPTER VI

PRACTICAL USE OF THE QUARTZ MERCURY VAPOUR LAMP IN GENERAL PRACTICE: OTHER CASES

A LARGE number of cases of the types reviewed in Chapter IV. will present themselves for treatment in any general practice, but in addition very many cases not coming within the scope of a public health department will seek advice and treatment from their own private doctor.

It is not the writer's intention to classify diseases in any particular way, and to record results or alleged results of treatment with ultra-violet radiation. It seems wiser to outline certain other common conditions met with in the routine of every day, where ultra-violet radiation may be confidently expected to give satisfactory results in the majority of patients. With these cases as a basis of experience the practitioner can enlarge the field of his endeavour.

Rheumatic Diseases.—Any busy practitioner will agree that he is occupied to a large extent with a huge group of what may be termed rheumatic diseases. Indeed, it has been shown that one-sixth of the industrial invalidity of this country is due to "rheumatism." Such conditions as sciatica, neuritis of various forms, lumbago, muscular rheumatism, fibrositis in adults, and chorea, nervous fidgety states, and subcutaneous nodes in children, yield decidedly and often with astonishing rapidity to ultra-violet radiation properly administered. Indeed, one may almost predict that after a short experience of radiation treatment in these cases, the exhibition of the usual drugs will take a second place.

Illustrative Cases

Sciatica.—A series of trial windows (see p. 24) are made on the skin of the arm or abdomen, and a third degree

erythema is produced along the course of the sciatic nerve on the affected side, and also over the lumbar region. In addition, gentle irradiation is applied at later sittings to the whole body. Relief of pain and improved night's sleep is obtained as a rule from the very beginning. The general light-bath may be given every second day, and the strong local erythema produced once every four to seven days. Some cases, even those of long standing, yield rapidly, while other cases require a few weeks' treatment.

Mrs. B., Aged Thirty-four (Sciatica of Left Leg).

History.—First attack September, 1922, during first pregnancy. Continued till March, 1923, when she could get about with some difficulty. Some five weeks after confinement, in May, 1923, pain returned and lasted for some months, during which period patient was helpless. Free from serious pain until Whitsuntide, 1925, when she was laid up in bed for four weeks. Relapsed again in August, 1925, and lasted six weeks. Another attack, very crippling in character, occurred in October, 1925, and persisted. Patient in bed more or less for three months. Numerous forms of treatment were tried during above periods, including removal to a nursing home, liniments, paints, radiant heat, diathermy, injections into sciatic nerve, stretching of nerve, mustard packs and baths, and drugs, including morphia.

At the end of January, 1926, the patient was crippled with constant pain in left thigh and in lumbar region, and suffered from general aches and pains from faulty position. Could not dress or undress herself, and every movement occasioned pain. Sleep disturbed, patient's condition very bad, and mental outlook dispirited.

Feb. 8, 1926: Ultra-violet radiation treatment commenced, patient arriving in a taxi-cab and having to be carried in. Four minutes at 6 inches up and down course of left sciatic nerve; four minutes at 6 inches up and down front of left leg; four minutes at 8 inches over lumbar region; five minutes at $2\frac{1}{2}$ feet over front and back of chest; felt improvement from these applications within twelve hours; patient seemed resistant to the rays, and showed only a second degree reaction over lumbar region.

Feb. 10, 1926: Eight minutes at 6 inches to back of leg only (first degree erythema); two minutes at 1 foot over lumbar region.

Feb. 13, 1926: Five minutes at 2 feet, general irradiation; four minutes at 6 inches, legs only; latter followed by small blister over one area, and marked third degree reaction.

Feb. 15, 1926: Repeated above; patient very much better; less pain; better movements; mental outlook greatly improved.

Feb. 17, 1926: Five minutes at 6 inches, leg and ankle.

Feb. 20, 1926: Five minutes at 2 feet, general irradiation.

Feb. 22, 1926: Five minutes at 2 feet, general irradiation, and five minutes at 6 inches locally to legs; patient continued to improve.

Feb. 24, 1926: Five minutes at 1 foot over thigh and left leg.

Feb. 27, 1926: Five minutes at 1 foot over thigh and left leg.

March 3, 1926: Eight minutes at 2 feet, general irradiation; no reaction.

March 6, 1926: Eight minutes at 2 feet, general irradiation; patient doing house-work and very active.

March 10, 1926: Eight minutes at 2 feet, general irradiation.

March 13, 1926: Eight minutes at 2 feet, general irradiation; neuritis right arm; four minutes at 6 inches to right arm.

March 16, 1926: Eight minutes at 2 feet, general irradiation, and four minutes at 6 inches to right arm; neuritis persists, but less severe.

March 19, 1926: Eight minutes at 2 feet, general irradiation, and four minutes at 6 inches to right arm; neuritis cured.

March 24, 1926: Eight minutes at 2 feet, general irradiation.

March 26, 1926: Patient so much better that she attended a dance, and was most lively and active the whole evening; total treatments given to date, sixteen; patient wishes to continue treatment for some weeks, as the "sun-baths" make her feel so strong and well; now able to play golf.

Lumbago and Fibrositis.—Dramatic results are often obtained in this distressing complaint. Give five minutes at 1 foot over the lumbar region for first dose, and repeat in two days, adjusting dose as indicated. Often prompt relief follows one dose, the patient returning to work. It is wise to give general light-baths as a preventive of any recurrence of the attacks.

A man, aged thirty-eight, subject to lumbago, and usually laid low for ten to fourteen days, was irradiated for five minutes at 1 foot over dorso-lumbar region. Next day an intense third degree erythema appeared; lumbago was gone, and he was back at his work as an electrician.

A sanitary inspector had a severe torticollis. Five minutes' irradiation at 1 foot to the affected area produced a third degree erythema, and he was cured next day.

Brachial Neuritis—*F. W., Male, Aged Fifty-eight.*—Brachial neuritis; pain over right shoulder and right upper arm, gnawing in character, always present, interfering with work as a garage attendant; treated by drugs for six months with no improvement; disturbed sleep; loss of weight.

Feb. 16, 1926: Ultra-violet radiation treatment commenced with eight minutes at 8 inches over affected areas; reaction third degree; reported good night's rest and less pain next day, which did not resume its old intensity.

Feb. 19, 1926: Second treatment, ten minutes at 1 foot; reaction third degree; reported great relief of pain and increased movements possible.

Feb. 26, 1926: Third treatment, five minutes at 8 inches over shoulder and upper arm, and two minutes at 6 inches over lower cervical spines; reaction second degree; reported no further pain, except on attempting to reach a high peg on the wall.

March 5, 1926: Cured.

G. H., Male, Aged Forty-five.—Doctor. Severe neuralgia down right arm and round to right scapula; unable to hang hat on peg owing to pain; disturbed sleep.

Jan. 5, 1925: Ultra-violet radiation commenced; complained of increase of pain during irradiation* and also at several subsequent sittings; pain almost ceased twelve hours later after erythema developed; then returned within twenty-four hours, but less severe.

Jan. 11, 1925: Still pain right arm, but less severe; ultra-violet radiation to body and locally to arm.

Jan. 18, 1925: Pain almost gone (fourth treatment).

Feb. 8, 1925: Pain gone.

March 26, 1925: Pain gone; very pleased with result, and stated that relief from pain was noted in about twelve hours from the earliest dose; no marked erythema was produced, except with first dose; ten treatments.

Trigeminal Neuralgia—*Mrs. P., Aged Forty-five.*—History of severe shingles in 1914, involving area supplied by fifth to seventh dorsal roots; lasted six weeks, and was very painful; in 1905 developed severe neuralgia of right side of face;

* This is most unusual.

from zygoma down the whole right side of face was very tender, and the slightest draught caused intense pain.

Treatment.—Had all teeth removed; antra explored and drained; nasal septum straightened; tonsils removed; condition defied all treatment, and patient was worn and ill; removal of Gasserian ganglion was contemplated; referred with above history by her own doctor for trial of ultra-violet radiation.

March 25, 1925: Ultra-violet radiation commenced; three minutes at 3 feet to body, and three minutes at 4 inches to face.

March 30, 1925: Pain less.

April 3, 1925: Pain gradually lessening.

April 17, 1925: Pain much less frequent; a few hours' respite from pain.

May 4, 1925: No pain for a week at a time, the first time she has been quite free from pain in the winter for eleven years.

May 22, 1925: Cold winds; return of pain; hyperæsthesia now only present on right side of nose, and over a small area on right malar prominence.

June 16, 1925: Pain gone again; treatment continued.

Sept. 22, 1925: No further relapse; patient is hardly recognised by neighbours, so much have her apppearance and expression improved; she is slightly thinner, livelier, and gets out and about more.

Total irradiation : 441 minutes.

The analgesic effect of ultra-violet radiation shows itself in these cases from the earliest doses, and comes on within twelve hours of irradiation.

In the last case quoted mild general light-baths were given, but severe third degree local reactions were produced on the right side of the face.

Respiratory Diseases.—Bronchitis, nasal catarrh, repeated "colds," and debilitated states form another large group of cases. Here results with ultra-violet radiation are not so consistent as in the preceding group of "rheumatic" diseases, but a course of a dozen or so "light-baths" often does much to raise the patient's resistance, especially in young persons and children suffering from what is conveniently termed general debility. As a rule, bi-weekly exposures back and front of three minutes at 3 feet are

sufficient, increasing to five or six minutes. In the case of patients subject to repeated "colds," it is wise to commence with a smaller dose, for sometimes the catarrh is made worse. These patients are usually found to possess a low blood pressure. The depression and malaise met with after febricula and influenza yield rapidly to irradiation, but dosage in these cases must be very gradual, and the rule is to avoid any erythema reaction in the initial doses. Later, small areas about 9 inches square may be irradiated more strongly and a first degree erythema produced.

Illustrative Cases

E. S., Female, Aged Eleven Years and Eight Months.—Child had pneumonia right side early in 1924; since then has had constant cough and expectoration; very thin, pallid, and listless; poor appetite; X-ray screen examination showed a marked fibrosis at right base, and diminished movement of right diaphragm.

Dec. 10, 1924: Ultra-violet radiation commenced; three minutes at 3 feet. Height, 4 feet 7 inches; weight, 4 stone 11¼ pounds.

Jan. 5, 1925: Six minutes at 3 feet; reaction first degree; improving. Weight, 5 stone 1 pound.

Jan. 26, 1925: Six minutes at 2 feet; improvement in appearance; cough almost ceased. Weight, 5 stone 3 pounds.

Feb. 4, 1925: Grandfather wrote to clinic commenting on increased energy and the cessation of cough.

March 16, 1925: Discharged; appearance quite transformed; no cough; expansion at bases good; right base normal, except for slight harsh inspiration. Height, 4 feet 9 inches; weight, 5 stone 6 pounds; gained 8¾ pounds in weight and grew 2 inches.

Total irradiation : 190 minutes.

Sept. 14, 1925: Inspected; now a big, sturdy girl. Height, 4 feet 9½ inches; weight, 6 stone 1½ pounds; very well.

Debility—*C. B., Male, Aged Twelve Years and Six Months.*—Referred by his doctor for ultra-violet radiation treatment, as no improvement with ordinary lines of treatment; boy overgrown and with a history of delicacy from birth; stated to have had slight dilatation of heart with irregularity of pulse; boy very languid, pallid, nervous, and with no appetite; blood pressure, $\frac{140}{80}$.

Oct. 19, 1925: Treatment commenced with general irra-

diation for two minutes at 4 feet bi-weekly, back and front; after fourth treatment he looked and said he felt brighter.

Oct. 26, 1925: Dose, two minutes at 3 feet.

Nov. 6, 1925: Dose, four minutes at 3 feet, and continued at this time and distance.

Feb. 15, 1926: Discharged cured; had thirty-five treatments in all; boy's whole appearance changed; looks fit and well; no longer nervous; good appetite and plenty of energy; blood pressure now $\frac{124}{74}$; has grown $1\frac{1}{2}$ inches and gained 8 pounds.

Whooping-Cough.—As already mentioned, exceptionally encouraging results are met with in these cases (see p. 45). The following illustrative case is given:

T. L., Female, Aged Three Years and Three Months.—Ultra-violet radiation treatment commenced at end of first week of the disease; child having thirteen attacks of coughing and whooping in twenty-four hours, with many attacks of vomiting.

Feb. 24, 1926: Three minutes at 3 feet, back and front; mother reported that during following twenty-four hours she recorded two attacks of coughing and whooping, and two attacks of vomiting.

Feb. 26, 1926: Three minutes at three feet; whooped once; coughing attacks, two; vomited twice.

March 1, 1926: Three minutes at 3 feet; whooped three times; cough, four; vomited once.

March 3, 1926: Four minutes at 3 feet; whooped twice; coughing attacks, four.

March 5, 1926: Four minutes at 3 feet; coughing attacks, one.

March 8, 1926: Four minutes at 3 feet; coughing attacks, two.

March 10, 1926: Four minutes at 3 feet; no coughing or whoop or sickness since March 8, 1926.

March 12, 1926: Four minutes at 3 feet; slight coughing attack twice; child looks well, and is lively; grandmother and mother well pleased with result in this case, and in case of her sister, aged one year, being astonished at the rapid relief compared with the experience of other children they had nursed.

Skin Diseases.—In this field the general practitioner will find most encouraging and often surprising results. Many cases of chronic nature, which have resisted all kinds of treatment, in hospital and otherwise, will be found to

improve rapidly, and to clear up under ultra-violet radiation. In the matter of dosage, moist eruptions should have stronger initial doses than dry eruptions, and as the skin heals the dose may be somewhat reduced, or the intervals between treatments lengthened. As a rule, applications should be given every second day to the lesions, with general irradiation of mild degree to the whole body once or twice a week.

Good results have been obtained by the writer in cases of septic dermatitis, acne, eczema of the face, scalp, ears, and body, lupus and scrofuloderma, xerodermia, psoriasis, food rashes of a chronic and baffling nature, burns, impetigo, chicken-pox, herpes zoster, and some forms of trade or occupational dermatitis.

The practitioner will readily extend this list, and in cases of doubt treatment of a localised area through a window in tissue-paper will soon indicate whether ultra-violet radiation is likely to be of benefit or not.

In connection with certain of the above conditions, the writer has found a marked tolerance to ultra-violet radiation and lack of response on the part of the skin itself. This has been chiefly noticed in connection with psoriasis and xerodermia, or in patients with dry, scaly skins.

In several instances where improvement was tardy or absent, immediate benefit resulted by using eosin or erythrosin as a "light sensitiser." Painting on solutions of eosin gave no appreciable result, but success followed feeding with tablets containing $1\frac{1}{2}$ gr. eosin. One tablet was given three times a day in a spoonful of jam for fourteen days, followed by fourteen days' rest, and so on. It is necessary to warn the patient that the urine and fæces will become red. No harm was seen to result in any case, and the method is well worth a trial.

Psoriasis limited to arms and legs responds well to ultra-violet radiation. Such cases would probably benefit from a combined course of ultra-violet radiation and X rays.

In **Herpes Zoster,** if the case can be irradiated at the onset of the attack, the disease may be apparently aborted. In any case, the relief obtained from pain and the extreme skin sensitiveness often met with is most pleasing to the patient.

About five minutes at 1 foot over the affected area with the open lamp and a slightly less exposure over the dorsal spines involved are indicated.

Cases of acne vulgaris respond in a most satisfactory manner. On the face, second or third degree reactions are usually required, but the second case quoted later on with severe acne of the chest and back responded in the most remarkable way to mild irradiation without the production of any uncomfortable reaction.

Illustrative Cases

Septic Dermatitis—*H. H., Male, Aged Three and a Half Years.*—Child had suffered from a septic dermatitis for one and a half years; repeated pimples, pustules, and multiple small boils all over the body, with marked scarring; boy looked debilitated and dispirited; anæmic; Hb, 75 per cent.; resisted all treatment.

Sept. 9, 1925: Three minutes at 3 feet, general irradiation back and front, arms and legs; reaction, first degree; improvement observed from first dose; treatment continued three times a week, the dose gradually increasing to seven minutes at 3 feet; the small pustules and boils rapidly healed; treatment continued, however, as fresh crops of septic spots kept appearing, on trunk especially.

Nov. 16, 1925: Boy's general health definitely better; appetite and energy normal, and increased cheerfulness.

Jan. 25, 1926: Dose increased to nine minutes at 3 feet, which produced a slight second degree erythema, and child rather languid next day; dose continued, however, as skin condition improved more rapidly.

Feb. 15, 1926: Discharged improved; child still gets a few pimples now and then, but these do not form small boils; all sores healed, leaving scars; Hb, 85 per cent.

Total treatments: Fifty-four.

Acne Vulgaris—*J. O., Male, Aged Thirty-seven Years.*—Marked acne vulgaris on chest and back; duration, twenty years.

Dec. 30, 1924: Ultra-violet radiation commenced; three minutes at 3 feet, back and front, which produced in this case mild erythema reaction of the first degree.

Jan. 10, 1925: Five minutes at 2 feet; third irradiation; acne decidedly improving.

Jan. 17, 1925: Seven minutes at 2 feet; fourth irradiation; acne almost gone.

FIG. 16.—September 25, 1925

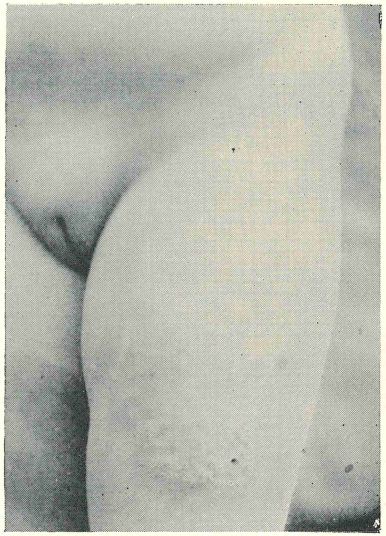

FIG. 17.—February 15, 1926

ECZEMA OF THIGH AND LEFT BUTTOCK : E. B., AGED 7 YEARS; DURATION, 2 YEARS

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Feb. 8, 1925: Acne cured after seven treatments.

May 5, 1925: Inspected; no sign of relapse.

V. P., Female, Aged Nineteen Years.—Acne on forehead and on lower face and chin; a few spots on shoulder; duration, five years.

March 23, 1925: Ultra-violet radiation commenced; three minutes at 3 feet, general irradiation; three minutes at 2 feet to face.

April 27, 1925: Slight improvement upper face; dose, five minutes at 1 foot.

May 29, 1925: No further improvement; chin, i.s.q.; slight loss of weight.

Aug. 26, 1925: Discontinued treatment; acne not improved on chin, but cleared up on forehead and back.

Acne Rosacea.—Mild forms of acne rosacea have also yielded to treatment. Here a second or third degree erythema was required.

Chronic Eczema of Thigh and Buttock—*E. B., Female, Aged Seven and a Half Years.*—Chronic eczema of thigh and left buttock; duration, two years.

Sept. 25, 1925: Treatment commenced with local irradiation, four minutes at 2 feet, and general irradiation of two minutes at 3 feet.

Oct. 14, 1925: Progressive improvement; local irradiation the same, with increase of general irradiation to three minutes at 3 feet.

Jan. 21, 1926: Increase of local irradiation to five minutes at 1 foot for several doses, as eczema almost gone; general irradiation also increased to five minutes at 3 feet; this was continued with satisfactory results.

Feb. 15, 1926: Child discharged cured; total treatments, twenty-five in all; the child's general appearance and health greatly improved; grew 1 inch in height and gained $2\frac{3}{4}$ pounds in weight.

Chronic Eczema of Scalp and Ears—*D. L., Female, Aged Six Years.*—Severe eczema of scalp and ears; duration, three years; had attended skin hospital and numerous doctors, with no improvement; child out of school for two years; head covered with one large crusted scab; ears cracked and moist.

Jan. 27, 1926: Five minutes at 1 foot to scalp.

Jan. 29, 1926: Six minutes at 8 inches to scalp; attempts made to remove crusts and scabs with starch poultice, and ultra-violet radiation treatment continued with bi-weekly doses of six minutes at 8 inches to scalp and five minutes at

2 feet to side of head (ears); improvement was slow but continuous.

March 12, 1926: Ears quite dry and healed.

March 22, 1926: Scalp cured; child sent back to school; hair growing well; sixteen treatments in all.

Eczema of Face—*Mrs. C., Aged Thirty-six Years.*—A dry eczema of face and wrist developed after birth of first child, July, 1925; duration, seven months; attended hospital for six months, but all applications failed to relieve the condition.

Feb. 8, 1926: Irradiated three minutes at 2 feet to face only every second day; after four treatments rash almost cured on face, but new patches on right forearm and back of neck *in statu quo.*

March 1, 1926: Treatment continued to face and begun on back of neck and arms, four minutes at 2 feet.

March 22, 1926: Condition cured; total treatments, ten.

Psoriasis—*L. W., Female, Aged Fourteen Years.*—Extensive psoriasis over trunk and limbs; duration of attack, three months; general health poor.

March 29, 1925: Irradiated three minutes at 3 feet with unhooded lamp to back and chest and arms, given every third day; no reaction till five minutes at 2 feet given; this was followed by slight erythema.

July 13, 1925: Skin lesions improving slowly.

Aug. 31, 1925: Eosin (1 per cent.) painted over abdominal spots; dose of eight minutes at 2 feet given; no improvement seen; increased crusting over spots painted, and possibly a slightly greater tendency to erythema.

Sept. 14, 1925: Eosin ($1\frac{1}{2}$ gr.) given t.i.d. by mouth, and dose of ultra-violet radiation six minutes at 2 feet; patient now definitely more sensitive, and psoriasis now began to improve rapidly.

Dec. 23, 1925: Psoriasis on trunk cured; a few patches on legs; obtained work and looks fit and well; continuing treatment to legs.

This case illustrates a resistant type of psoriasis, which only yielded to ultra-violet radiation when eosin was given internally as a sensitiser.

D. H., Female, Aged Seventeen Years.—Lesions marked on trunk, front and back; duration, ten years; ultra-violet radiation has produced no evidence of improvement after 186 minutes' irradiation, although general physical condition has improved.

FIG. 18.—Before treatment (March 3, 1926)

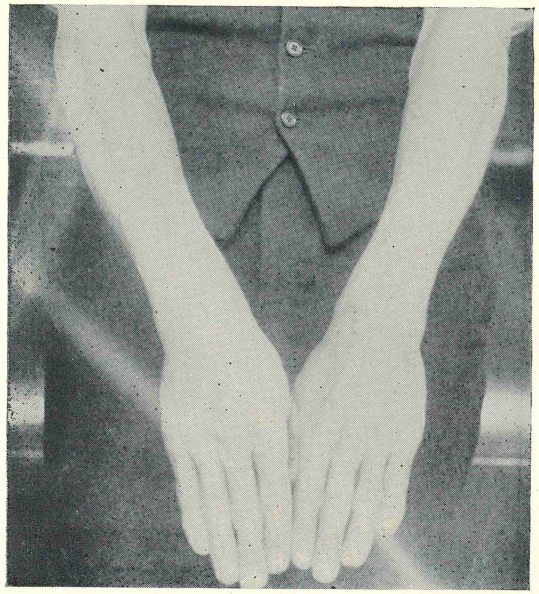

FIG. 19.—After treatment (March 17, 1926)

FORMALIN DERMATITIS : J. S.

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Formalin Dermatitis—*J. S., Male, Aged Fifty-three Years (Severe Formalin Dermatitis).*—Patient off work as a disinfector in health department; had severe formalin dermatitis for over three weeks, involving hands and both arms up to the elbows; right ear also affected; ordinary treatment with calamine lotion, etc., failed; sent by panel doctor to try effect of ultra-violet radiation; the rash looked very formidable, and a trial area of 6 inches by 4 inches was irradiated for four minutes at 20 inches; result remarkable and dramatic.

March 3, 1926: Second day. This area was so definitely improved that both arms were freed from lotion as far as possible, and irradiated for four minutes at 20 inches; marked improvement all over; reaction slight; great relief from skin irritation.

March 5, 1926: Eight minutes at 20 inches; continued improvement.

March 8, 1926: Ten minutes at 20 inches; reaction third degree.

March 10, 1926: Ten minutes at 20 inches; reaction second degree +; arms almost cured.

March 12, 1926: Fifteen minutes at 20 inches; arms and hands well, except for a few isolated patches here and there.

March 17, 1926: Two minutes at 6 inches to few remaining patches; man cured and returned to work.

The right ear healed up after three doses of ultra-violet, radiation of two minutes at 8 inches.

Formalin dermatitis is a most resistant disease to treat, and the above result was most satisfactory.

ULTRA-VIOLET RADIATION IN OTO-RHINO-LARYNGOLOGY

Otology: Otorrhœa, Deafness, etc.—Considering the effects of ultra-violet radiation in raising the patient's resistance against infections and the direct bactericidal effect on tissue surfaces, it seems reasonable to expect some improvement in certain ear conditions by combining general irradiation of the body with local irradiation of tympanic cavity, either through a speculum or by means of a " medical " lamp with quartz rod inserted in the canal.

Literature on the treatment of otorrhœa by ultra-violet radiation is somewhat scanty, but it would appear that radiation is now being recognised chiefly in America as a valuable aid to the treatment of ear disease.

Hollander and Cottle report success with the Kromayer water-cooled lamp, giving one-minute exposures through a quartz rod up to three minutes, at first daily and then three times a week. A 2 per cent. mercurochrome solution was also used in these cases as an instillation. They lay stress on the necessity for correcting pathological conditions of the nose and throat, and excluding cases with caries of the bone. Their cases showed cessation of the discharge after eight to twelve treatments.

Cemach claims good results from radiation in cases of eczema of the canal, and in boils in the canal.

In this country Burroughs* reports good results from irradiation of the tympanum through a speculum from a tungsten arc. He gave one-minute exposures at first, repeating the treatment every two or three days, and gradually increasing the exposure. He definitely notes that hearing improves after five or six treatments.

Method with Quartz Mercury Vapour Lamp.—(*a*) Irradiate the chest and back of the patient with the unhooded lamp daily for two to three minutes at 20 to 30 inches from the burner. While sitting with the back to the lamp, instruct the patient to turn the head first to one side and then to the other, so that the mastoidal regions get the benefit of the rays.

(*b*) Cover the patient with a blanket, protect the face with a sheet of tissue-paper, insert a speculum through the centre of this into the meatus. Place the burner 4 to 6 inches from the speculum, and irradiate at first for three minutes, increasing each day to six or eight minutes, the larger doses being continued every second day.

If a " medical " lamp is available, then proceed as in (*a*), and continue by inserting a quartz rod pencil applicator into the meatus, commencing with half to one minute, and increase daily to five minutes, or longer in some cases.

Illustrative Cases

A. U., Aged Nine Years.—Double otorrhœa since infancy; duration, eight years; treated at a school clinic by " routine "

* W. S. Burroughs, *Lancet*, October 29, 1921, p. 901.

methods for first time in August, 1925; after three months dried up; child very deaf, and can hear a whisper at 4 feet only; on examination: excoriated nares, ears dry, both drums destroyed.

Feb. 15, 1926: Both ears irradiated for two minutes at 8 inches; no pain; chest and back irradiated for two minutes at 30 inches; reaction first degree back.

Feb. 16, 1926: Both ears irradiated for three minutes at 6 inches; no pain; no reaction.

Feb. 17, 1926: Both ears irradiated for four minutes at 6 inches; hears better with left ear; chest and back irradiated for three minutes at 30 inches; no reaction.

Feb. 18, 1926: Both ears irradiated for five minutes at 6 inches; slight headache.

Feb. 23, 1926: Both ears irradiated for four minutes at 6 inches; no pain; chest and back irradiated for three minutes at 20 inches; no reaction; general appearance improved; ears dry; can hear a whisper now at 8 feet; discharged improved.

C. P., Aged Eleven Years.—Left otorrhœa since August, 1925; cause unknown; attended school clinic for weeks; dried up; relapsed January, 1926; slight deafness; intractable moist eczema behind ear; on examination: inspissated foul-smelling discharge, drum œdematous, small boil in meatus.

Feb. 15, 1926: Left ear irradiated for two minutes at 8 inches; no pain; chest and back irradiated for two minutes at 30 inches; no reaction; eczema behind left ear given half minute at 8 inches (also on subsequent dates).

Feb. 16, 1926: Left ear irradiated for two minutes at 8 inches; less discharge; vomited once; eczema drying up.

Feb. 17, 1926: Left ear irradiated for three minutes at 8 inches; ear almost dry; eczema dry; hears better.

Feb. 18, 1926: Left ear irradiated for four minutes at 8 inches; slight increase of discharge, but not so foul; eczema practically healed.

Feb. 20, 1926: Left ear irradiated for four minutes at 8 inches; discharge ceased by February 22, 1926; swab on probe slightly moist; eczema cured.

Feb. 23, 1926: Left ear irradiated for five minutes at 8 inches; ear dry.

Feb. 24, 1926: Left ear dry; boil in meatus cured; eczema cured; hears quite normally.

March 8, 1926: Reported well; discharged cured.

In the writer's opinion ultra-violet radiation is of great benefit in the treatment of canal furunculosis, and of help

in some forms of catarrhal deafness. In that most intractable condition—post-aural eczema in children—which resists ordinary treatment, and where fresh fissures and cracks keep forming, ultra-violet radiation is almost a specific.

In otitis media, by far the best results are obtained by ionisation with zinc sulphate on the lines laid down so ably by Dr. A. R. Friel. In the absence of such treatment it is worth while to try ultra-violet radiation, especially if quartz rod applicators and a " medical " lamp can be used.

Rhino-Laryngology.—For the treatment of the following conditions a " medical " lamp, either air-cooled or water-cooled, with quartz rod applicators is an essential. The times suggested apply to a water-cooled lamp; if an air-cooled lamp is used, the initial doses should be slightly less.

Nasal Catarrh.—Carefully swab out nasal passages before irradiation with 2 per cent. bicarbonate of soda. If crusts are present, a good plan is to plug the nostrils, leaving the patient for ten minutes, and then remove crusts which are now softened, with the bicarbonate solution. A cocaine spray may be necessary to anæsthetise the mucous membrane before inserting the applicators.

When treating acute coryza and other nasal catarrhs, commence with three minutes each nostril, and combine with a mild general irradiation daily.

In chronic nasal catarrh, increase the dose at each irradiation to each nostril, and give slightly longer general irradiation. Treat twice a week.

Acute Tonsillitis.—A single irradiation of about four minutes direct on the tonsils will very often cut short an attack. If no applicator is available, eight minutes at 8 inches through a metal tube from the air-cooled lamp may produce good results.

Chronic Tonsillitis.—Treat once a week with increasing doses, combined with general irradiation. Prolonged treatment is often required.

Pharyngitis.—Here a quartz applicator slightly curved is used, and passed through the nostril or behind the uvula. Give treatments twice weekly, commencing with three-

FIG. 20.—August 28, 1925

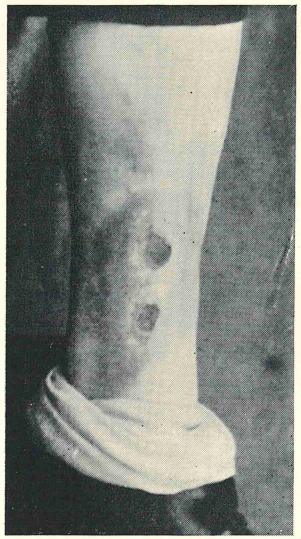

FIG. 21.—September 16, 1925

VARICOSE VEINS: MRS. X., AGED 36; COMMENCED TREATMENT, AUGUST 14, 1925

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minute doses and increasing. Remember that the rays follow the curve of the tube and emerge at the point, so that the applicator is gently twisted about *in situ* in order to distribute the rays as much as possible. The amount of increase in the dosage will depend upon the tolerance of the patient.

Laryngitis.—Use a curved quartz applicator, giving an initial dose of three to four minutes bi-weekly, and increasing the dose gradually. Additional improvement may be obtained by producing a second or third degree reaction over the front of the neck once a week with the ordinary lamp.

In coryza, many forms of nasal catarrh, acute tonsillitis, and pharyngitis (acute and chronic) results are good, but patience and time are required in cases of chronic tonsillitis and chronic nasal catarrh.

Other Types of Case.—Beneficial results have also been obtained in conditions such as keloid scars, chilblains varicose ulcers of legs, chronic indolent sores and ulcers, and in furunculosis.

In all these conditions strong initial doses should be given, with production of well-marked reaction of the second degree, and in the case of keloid scars of a fourth degree or actual blister the latter repeated every third week. When granulation tissue forms, the dose is cut down, and healing rapidly takes place.

Illustrative Cases

Keloid—*G. E., Female, Aged Thirty-one Years.*—Revaccinated in 1921; bad arm; left bluish, much raised, unsightly scars; patient sensitive to ultra-violet radiation when given baths; local reaction fourth degree with quartz glass compressor produced on scar areas every three weeks; after eleven applications scars much reduced in size, not so raised, and bluish colour replaced by red; small areas white and soft; treatment continuing.

Varicose Ulcer of Leg—*Mrs. K., Aged Thirty-six Years.*—Two varicose ulcers on left leg, which have never healed in five years; recently spreading and causing pain, and patient unable to walk.

Aug. 14, 1925: Ultra-violet radiation, two minutes at 2 feet locally. Weight, 10 stone 12 pounds.

Aug. 17, 1925: Reports that pain in leg is much less.

Aug. 19, 1925: Ulcers healthier colour, and granulations appearing on surface.

Aug. 24, 1925: First photograph taken; definite improvement; dose now seven minutes at 1 foot.

Sept. 16, 1925: Second photograph taken; no pain now; great improvement; can walk well. Weight, 11 stone $2\frac{1}{4}$ pounds.

(Treatment continuing; patient unable to rest leg as she should owing to home circumstances, yet healing is taking place.)

General Tonic Effect of Ultra-Violet Radiation.—As a tonic in convalescents generally there is a very wide field for use in general practice of the quartz mercury vapour lamp for its tonic effects, particularly in convalescence after debilitating diseases—pneumonia, bronchitis, influenza, whooping-cough, infectious diseases, "run-down" conditions, and a host of other common ailments.

In such cases, initial doses of three minutes at 3 feet to the chest and back, repeated two or three times a week, and increasing gradually by one or two minutes a week at the same distance, usually prove satisfactory. In cases where the blood pressure is likely to be low, the initial dose should be one minute at 4 feet to the chest and back.

CHAPTER VII

PRACTICAL NOTES FOR THE GENERAL PRACTITIONER

1. Type of Apparatus to Buy

For the man in practice, what is wanted is a source of ultra-violet radiation which is reliable, cheap as to initial cost and running, free from complications and mechanical worries, and safe and handy to use.

At present there is only one source which fulfils all these requirements, and that source is the quartz mercury vapour lamp. There are two forms of burner available:

(*a*) **The Air-Cooled Vacuum Type** (100 to 220 volts), where the quartz burner is exhausted of air and contains a quantity

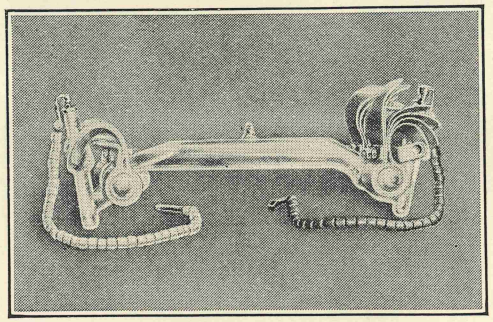

Fig. 22.—Air-Cooled Vacuum Type Burner (Hanovia). Direct Current.

of mercury. This lamp is started by tilting for a few seconds, and then returning to the horizontal. The mercury in the burner is free, and is apt to produce a water-hammer effect on handling the lamp or in transit, and such lamps are rather fragile. This type of burner may be used on a direct current supply, and also with alternating current supply with the use of a transformer. In the latter case there is a double positive pole in the lamp. Many of these lamps are of foreign manufacture.

(*b*) **The Air-Cooled Atmospheric Type of Burner** (K.B.B., 220 to 440 volts).—Here the quartz container is completely filled with mercury. The burner consists essentially of a fused quartz U-tube, one limb of which is hermetically sealed. The other is closed by a stopper carrying a tungsten electrode. The whole tube is filled with mercury. The arc is started by a small branch tube sealed into the body of the quartz burner and surrounded by a heating coil. When the circuit is closed by the switch, the coil heats up, boils the mercury, and the arc is struck between the two liquid mercury faces. The mercury travels up the open end of the U-tube, the arc lengthens, and the heating coil is auto-

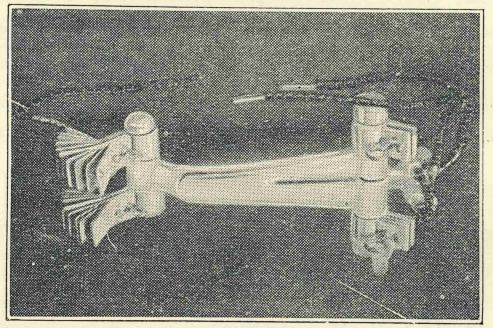

FIG. 23.—AIR-COOLED VACUUM TYPE BURNER (HANOVIA). ALTERNATING CURRENT, SHOWING DOUBLE POSITIVE POLE.

matically cut out. This burner works at 220 volts, and starting up at 5 amperes, soon settles down to burn at 2·5 amperes quietly and steadily. Four and a half inches from the burner the temperature is about 110° F. Aluminium radiating fins cool the burner. This lamp is less liable to sustain damage by handling or transit, and in the writer's opinion is the best type of burner. It is British made.

At present the atmospheric type of lamp will run only on direct current. Possibly before long a lamp of this type suitable for an alternating current will be evolved. Two types of air-cooled lamp of this form are on the market: a small burner for a 220 to 250 volt D.C. supply, and a larger burner for a 440-volt D.C. supply.

Resistance.—With these lamps a suitable series resistance is required—about 50 ohms with a 250-volt circuit—placed

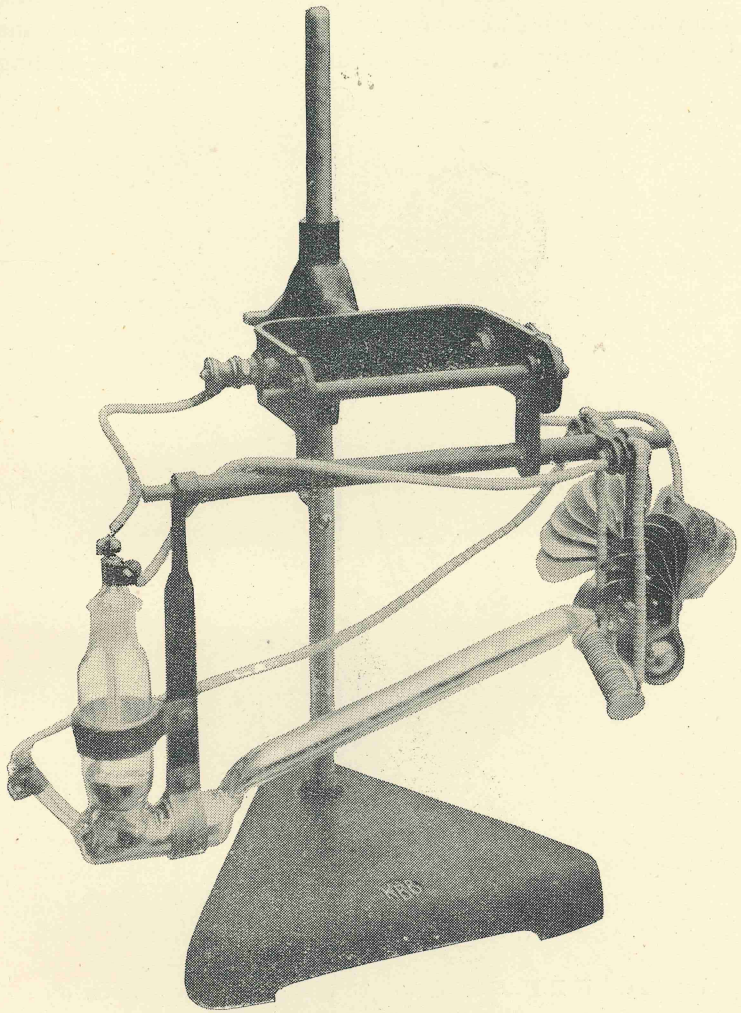

FIG. 24.—AIR-COOLED ATMOSPHERIC TYPE BURNER. K.B.B. 440-VOLT PATTERN.

either on the wall or forming part of the stand of the lamp. All the above lamps start up on a current of about 5 amperes, and quickly settle down to burn at from 2·5 to 3 amperes.

The above lamps are supplied mounted on stands with a balanced movable arm, or may be suspended from the ceiling with cords and adjusted to height by counter-weights. They may be used as naked arcs, or may be enclosed in some form of hemispherical metal hood, with one half sliding

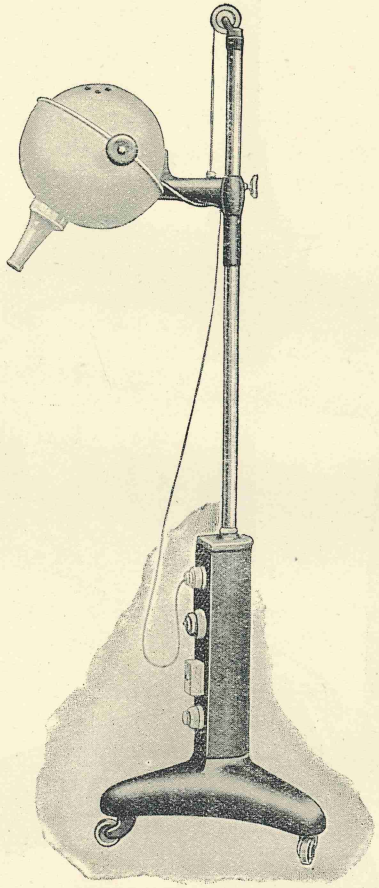

FIG. 25.—K.B.B. SUN LAMP, TYPE "A." RESISTANCE ON STAND.

back within the other. When open, the lamp is used for general irradiation; and when closed, cone applicators of metal or different-sized diaphragms over an aperture in the movable half of the hood serve to restrict the rays to localised surfaces.

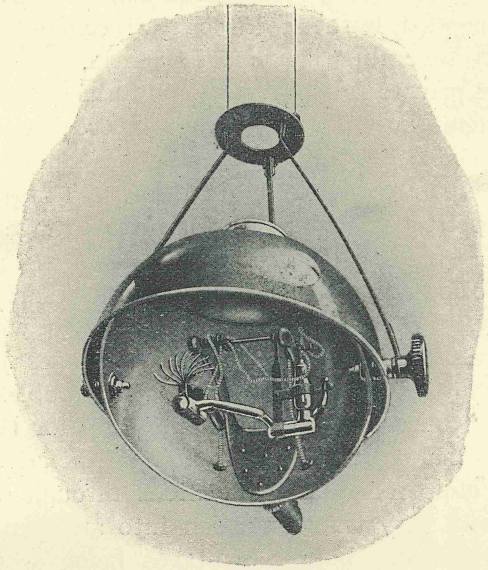

FIG. 26.—K.B.B. SUSPENSION MODEL: OPEN.

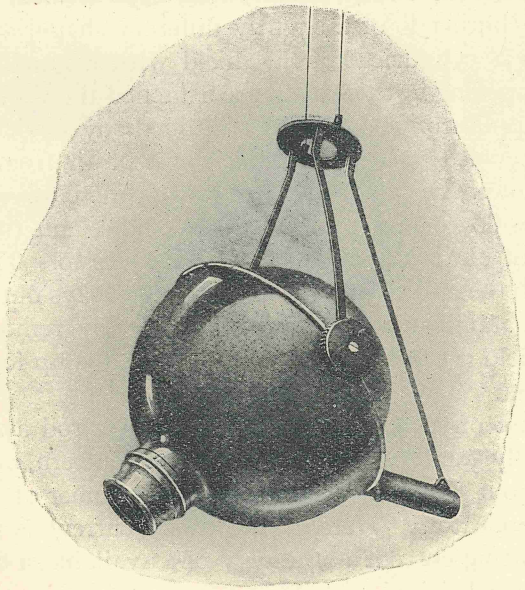

FIG. 27.—K.B.B. SUSPENSION MODEL: CLOSED.

For the public health clinic the writer recommends a simple unhooded burner with central ceiling suspension, round which several patients (six to eight) may sit at a time, but for the private practitioner some form of hooded lamp is more generally useful, as he cannot expect private patients as a rule to collect round the lamp at one time.

These lamps are reasonable in price, and most types of case can be treated by them. The prices range from £30 to £46.

For more specialised treatment of restricted areas in body cavities, water-cooled vacuum type burners with quartz rod applicators of different sizes and shapes have been available, but are rather liable to small troubles, and are expensive. Quite recently the ideal lamp for the general practitioner has been evolved, combining the advantages of a medical lamp for local applications through quartz applicators with easy transformation into an open lamp for general irradiation, both advantages being secured with an air-cooled burner. This is the—

(*c*) **K.B.B. Air-Cooled Atmospheric Type Medical Lamp.**—Here the burner is of a slightly different shape, and is enclosed in a cylindrical metal shield with a handle. To a circular opening in this shield are attached the various-sized quartz applicator rods for irradiating body cavities. The whole is cooled by a constant draught of air from a small motor blower, the air being led up from the blower through flexible hollow metal tubing to the handle, and thence the current of air is distributed round the lamp. This lamp appears to be more powerful in ultra-violet rays output than the more familiar water-cooled lamps. By removing the metal shield it can be used as an unhooded lamp for general irradiation.

The cost of such a lamp with its quartz rod applicators is naturally greater than the more simple pattern, and works out at about £60 to £70, with a limited number of generally useful applicators. Here, again, direct current is required. If alternating current is the only one available, a converter must be used.

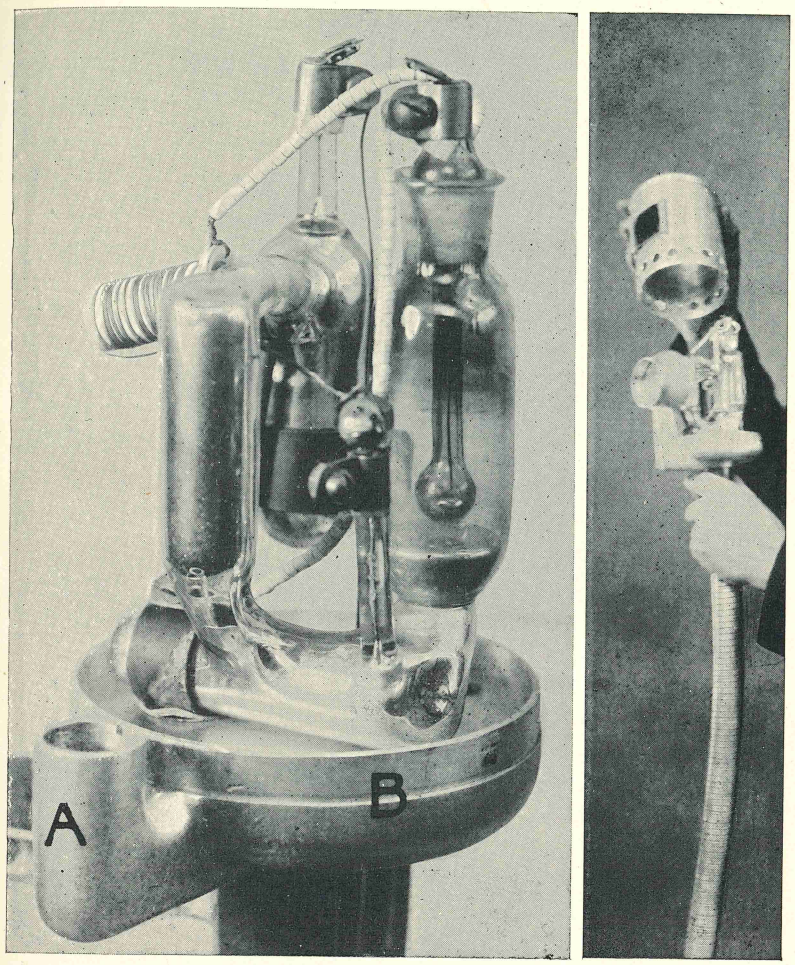

FIG. 28.—ATMOSPHERIC TYPE MERCURY VAPOUR ARC LAMP COOLED BY FORCED DRAUGHT

1. Shows the quartz arc lamp mounted on air chamber B. In the position shown it is used as an open arc lamp for general irradiation.
2. Shows the adapter for applicators in position, and the hood being placed in position to prepare the lamp for use with applicators, or for use with a sterilised air stream.

From "Practical Ultra-Violet Light Therapy," by Mackenzie and King (Ernest Benn, Ltd., London).

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2. Installation and Fittings

(*a*) **Treatment Room.**—In practice, if many patients are treated, the doctor will see the patient, prescribe the duration

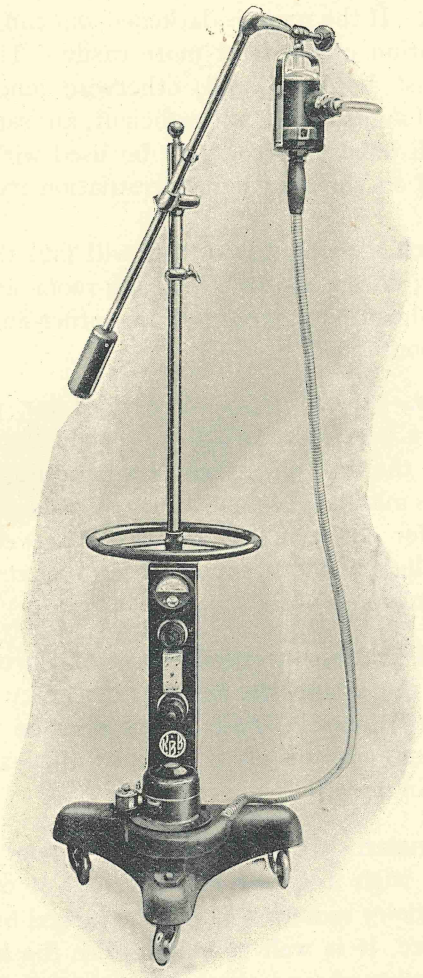

Fig. 29.—New K.B.B. Atmospheric Type Air-Cooled "Medical" Lamp, showing Air-Blower at Base of Stand and Quartz Applicator in Lamp.

of dose and the distance of the patient from the lamp, and hand over the actual treatment to a nurse, dispenser, or other

helper. It is wise, therefore, to instal the lamp, if possible, in a small room near the consulting-room. The room must be warmed by a gas fire preferably to 68° or 70° F. A comfortable lounge chair or small couch and a revolving stool are required. If the room is darkened, one can supervise the local application of the light more easily. The room temperature must be kept high, otherwise longer doses are required. If a gas fire be not sufficient, an ordinary electric radiator with bowl reflector may be used with advantage, and focussed on the area under irradiation from the ultra-violet lamp.

Failing such a room, the doctor will find that the lamp can occupy a corner of the consulting-room without inconvenience, and can be moved from its corner and used in the consulting-room itself.

(*b*) **Goggles.**—A few pairs of goggles for patients and operator are a necessity, as a few seconds' exposure of the naked eye to the rays will produce a painful conjunctivitis. These goggles may be obtained at a cost of 2s. 6d. for adults, and 1s. 6d. for children. The operator is well advised to purchase a slightly more expensive and more comfortable goggle for prolonged use.

(*c*) **Interval Timer.**—A special form of alarm clock is of the greatest importance in ensuring accuracy of the time element in treatment. These clocks may be obtained for about 21s., and can be set to ring at the expiry of any number of minutes up to sixty.

(*d*) **Actinometer.**—As quartz mercury vapour burners lose power slowly with use, and as their loss of output of invisible ultra-violet radiation cannot be judged by the brightness of the arc, it is well to standardise the lamp shortly after it is purchased, and check its activity from month to month. This can be done (i.) by time and distance method on the owner's forearm through a window cut in paper (see p. 24); (ii.) by the acetone methylene blue actinometer, where a small quartz tube of solution is exposed for a definite time at a definite distance, and time taken to discolorise is

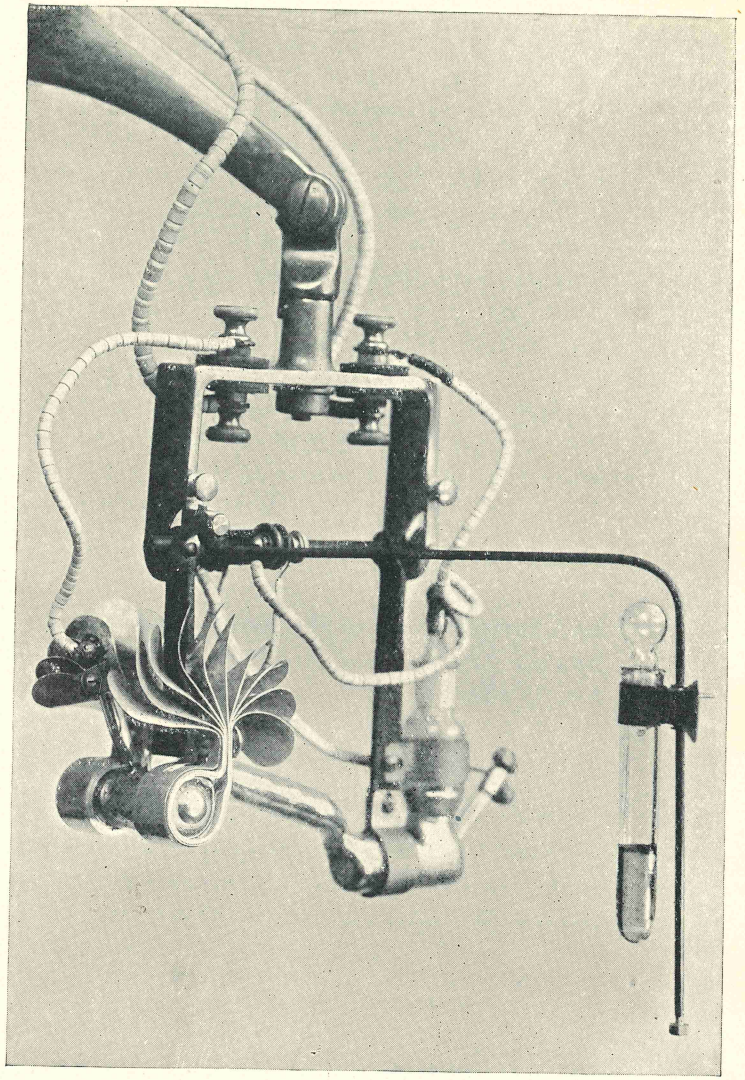

FIG. 30.—KING'S ACTINOMETER : THE 250-VOLT ATMOSPHERIC QUARTZ MERCURY VAPOUR LAMP IN ITS HOLDER AT THE END OF THE ARM OF THE STAND

The fused quartz test tube is in position for making a test.

From "Practical Ultra-Violet Light Therapy," by Mackenzie and King, (Ernest Benn, Ltd., London).

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noted; or (iii.) by *King's carbon-tetrachloride actinometer.** This is the best method, as the solution picks out the wave-lengths most useful in therapy—viz., all less than 2,650 Å. A quartz tube with stopper is held at 6 inches from the burner for three minutes by a distance rod and clip at right angles to the arc tube. One drop of 10 per cent. potassium iodide solution is added, and the tube shaken vigorously. A definite reddish tint is observed in the tube, which is deepest when the lamp under test gives the most ultra-violet radiation output. This tint may be compared with standard tints, and the ultra-violet radiation efficiency of the lamp stated in milligrams of iodine, or the contents of the tube may be kept in a small bottle and used for comparison with a test at a later date.

(*e*) **Paper.**—A supply of large sheets of ordinary tissue-paper will be found useful for protecting parts of the patient from over-exposure—*e.g.*, the face. Holes may be cut in the paper for treating small lesions, such as lupus, etc., with the open burner brought close up, if the lamp does not possess a hood and diaphragm.

(*f*) **Three-Foot Rule.**—A 3-foot rule or spring measuring tape, marked in inches, is used for ascertaining the nearest part of the patient from the centre of the arc.

3. Cost

(*a*) **Cost of Apparatus.**—This varies with different makes of lamps, different stands, etc. An unhooded burner, suspended from the ceiling with resistance on wall, can be obtained for under £22. The ordinary type of lamp with stand, hood, and resistance complete works out at from £32 to £40 for direct current type, and from £48 for alternating current type.

The new K.B.B. air-cooled medical lamp complete with air-blower and a selection of quartz applicators costs about £60 to £70.

* Obtainable from Kelvin, Bottomley and Baird, Ltd., 18, Cambridge Road, Glasgow.

(*b*) **Cost of Running.**—For the ordinary burner the cost of current works out at about 3d. per hour (250 volts) where the unit costs 5d. or 6d., and for the large 440-volt type round about 5d. per hour. Occasionally in the atmospheric type of lamp the heating coil fuses. A new coil is replaced in a few minutes at a cost of 3s. 6d.

4. Care and Upkeep of Quartz Mercury Vapour Lamps

See that burner stirrup or holder is horizontal, and that all terminals, nuts, and screws are tightened properly. Before starting up any quartz mercury vapour lamp wipe the burner each time with a linen cloth moistened with absolute alcohol, carbon-tetrachloride, or ether to remove finger marks or dust particles. If this is not done, the quartz soon becomes dirty and loses its transparency somewhat, thus limiting its output of ultra-violet rays.

If there is any doubt as to polarity with direct current supply, take the two wires leading to the lamp and place ends about 1 inch apart on some filter-paper moistened with potassium iodide solution. Switch on the current, and a brown mark will appear on the paper at the positive lead. This lead is attached to the burner where the + terminal is usually marked red. It is essential with direct current to have the polarity correct.

When started up, the burner should be allowed to run for about five minutes before treatment is commenced. It will then have reached its maximum intensity. Unless there is likely to be a considerable pause between patients or batches of patients, it is better to let the lamp burn than to keep switching it off and starting up again.

After switching off do not move or shake the lamp or stand until the burner has cooled down. When cool, in the case of the unhooded lamp, it is wise to cover it with a cloth or duster, to exclude dust settling on it.

Burners often refuse to start again when hot, as the mercury boils away from the hot quartz, and the arc does not strike. Allow to cool for a few minutes.

Switching on and Starting

Vacuum Type Lamps.—When the burner is in its stirrup, tilt with the small knob or wheel provided to get the mercury evenly distributed between both poles. Then

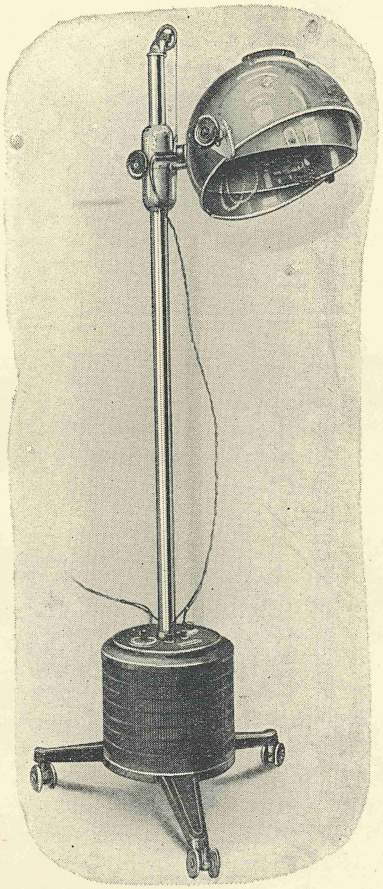

Fig. 31.—Alpine Sun Lamp: Standard Model. (British Hanovia Quartz Lamp Co.)

switch on the current, and with the small hand-wheel tilt the burner gently, and then lower it to the horizontal again. Direct current burners usually start up on the first or second tilting, but alternating current burners vary amongst them-

selves in this respect, and may require six or more tiltings. If a burner lights, flickers, and goes out readily, it is usually due to an imperfect vacuum. One sign of a good vacuum is a clicking noise and a slight thrill when the burner is tilted,

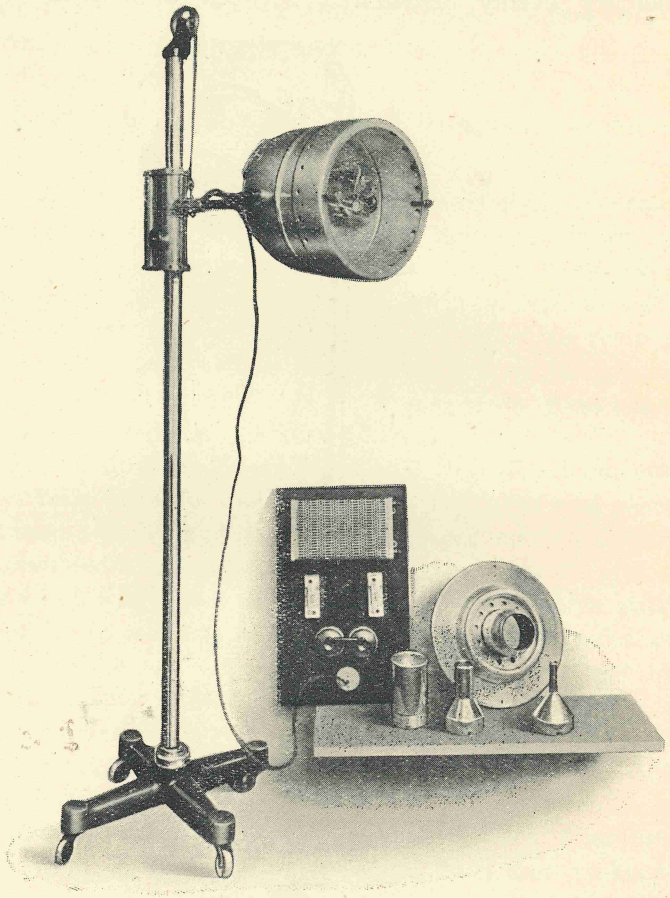

FIG. 32.—THE "MONTANA" MERCURY VAPOUR LAMP: D.C. MODEL, AUTOMATIC STARTING. (STERLING CORPORATION, LTD.)

whereas if the vacuum is defective the mercury flows with a dull kind of thud.

If the burner goes out after running for some time, it is usually due to over-heating (as with hood closed for a long period), or to faults in the leads or elsewhere. It may

occur that excessive voltage in the circuit is the cause of the extinction. This may be remedied by altering the adjustment on the resistance coil. The inherent fault with most burners of the vacuum type is fragility. Owing to the fact that they are exhausted to a high vacuum, and that they

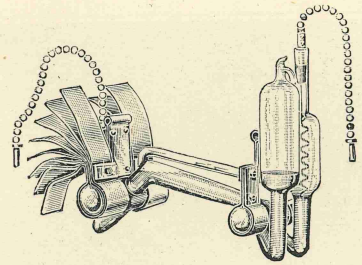

FIG. 33.—"MONTANA" BURNER: TYPE B. 220 VOLTS, 3 AMPS., AUTOMATIC STARTING.

contain heavy mercury, they are liable to be damaged by the slightest jar. There is on the market a type of burner which contains a heating element inside a tube of argon gas. To operate, one simply switches on; the heater causes the gas to expand, this passes down a side tube, parts the mercury in the main tube, and starts the arc. No tilting is required.

Atmospheric Type Burners.—Here the whole burner is filled with mercury, and, as explained elsewhere (p. 16), the arc is started by means of a small heating coil over a branch limb of the burner tube. See that polarity is right, and connect the + lead to the red terminal of the burner. This terminal is at the open reservoir end of the burner.

See that no air bubbles have got into the mercury during transit. Remove the glass stopper from the reservoir, and see that there is a small blob of mercury in the little cup in the bottom of the stopper. Replace stopper and switch on. The small heating coil should now glow, and after one or two minutes the arc starts up. Should the lamp not start up easily, or should the preliminary heating be accompanied by sharp clicking noises, then air has got into the burner. Switch off, allow to cool, remove burner from stirrup, tilt the reservoir end uppermost, and tap the burner with the

hand, when the air bubble will generally make its way up into the reservoir and escape. The only fault likely to develop with this type of burner is fusing of the heating coil. A couple of spare heating coils should always be kept handy, and it is a matter of a few seconds to remove the old one and

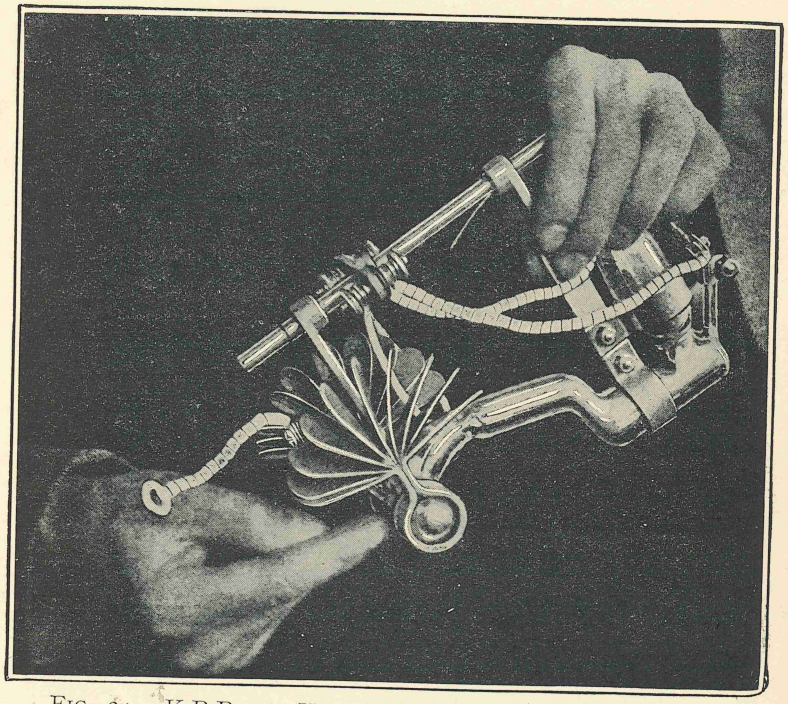

FIG. 34.—K.B.B. 220-VOLT BURNER: METHOD OF HOLDING.

affix a new one. These burners are much more sturdy than the vacuum type, and stand transit and handling with less risk of damage.

Bright Parts of Stand, etc.—The electro-plated parts of the stand, lamp stirrup, etc., may be kept clean and free from rust by rubbing over once a week with a rag moistened with " three-in-one " oil.

Replacement of Burners.—While a quartz mercury vapour burner has an almost indefinite life, as far as visible light is concerned, the action of the mercury arc on the quartz

gradually devitrifies it, and renders it opaque to ultra-violet rays. This process is gradual, but, generally speaking, a quartz burner should be reannealed at the works after 800 to 1,000 hours' use (this is roughly after two years' use in private practice), as continued use after this period would involve inconveniently long exposures and unnecessary waste of current.

Vacuum burners must be returned to the works for re-conditioning, which costs from £3 to £5.

Atmospheric type burners, if the quartz is not badly affected, may have the mercury extracted with the help of a vacuum pump. The container is then filled with nitric acid and left overnight. Next day the acid is removed, the reservoir washed out with alcohol and ether, and the mercury replaced after filtering through chamois leather or glass wool.

It is wise to have a spare burner, if possible, as a stand-by. These cost from £8 to £12, according to type.

5. HINTS ON DOSAGE FOR BEGINNERS

It is quite impossible to lay down hard-and-fast rules as to dosage, for lamps vary amongst themselves as to intensity of ultra-violet radiation output, and patients vary enormously as to their sensitiveness to the rays and the manner in which they respond. One or two guiding principles, however, are all that the practitioner requires, together with a reasonable modicum of common sense. Armed with these, he need not fear to go ahead, and in a very short time will feel himself gaining confidence and obtaining good results. In the first place, remember to proceed carefully with a *new* burner, as it is apt to be rather powerful during the first few hours of use. In a short time the burner settles down to a more uniform output of ultra-violet radiation. The times and distances hereunder mentioned refer to such a burner, so with new burners it would be wiser for the novice to give a minute less exposure.

Dosage of ultra-violet radiation is regulated by exposing the patient for a certain time at a certain distance from the lamp. The distance is measured from the nearest point of

the patient to the centre of the arc, and at right angles to it. The rule is the rule of inverse squares.

The intensity of the rays is in inverse proportion to the square of the distance from the burner. In other words, if a certain dose is given to a patient at 4 feet, when we move this patient to 2 feet from the lamp and allow the same time as before, such a patient gets *four* times the dose, and not twice the dose.

Another point to remember is that that portion of the patient at right angles to the centre of the burner gets the maximum amount of the rays—the normal ray. If the rays strike a patient at an angle to the normal, then an increase in the time allowance must be made. Thus, if rays strike at an angle of 60° about one-fifth increase of the time is required, and if at 45° an increase of two-fifths (cosine law). In practice, when giving general irradiation to a patient, make him recline in an easy lounge chair with his feet on a stool, and his body as far as possible forming a segment of a circle. Now fix the lamp as near as possible at the centre of this circle, and the patient will receive a uniform incidence of the rays.

Reactions.—After a latent period of four to six hours, a reaction of the part irradiated may show itself as an erythema. This is roughly divided into four degrees for clinical use:

Reaction, first degree: Faint, pinky blush on skin.

Reaction, second degree: Erythema of slight degree, followed possibly by slight itching and faint powdering.

Reaction, third degree: Marked erythema, with itching, smarting of skin, followed by coarse desquamation and pigmentation.

Reaction, fourth degree: Deep erythema with blisters, with œdema of parts, and followed by pigmentation.

In treating babies and young children, and some adults, even a first degree reaction is to be avoided. In the case of babies particularly, marked improvement is observed from general irradiation without the production of any erythema at all. The writer believes that the tendency in this country has been to over-irradiate babies.

Time and Distance.—Each patient, as a rule, must be considered separately, and the following are suggested initial doses only:

Dark patients generally stand larger doses than fair patients. It is often helpful to ask the patient how his skin is affected by a strong sun.

A large number of patients will be given ultra-violet radiation in the form of general irradiation (" light-baths "). In the case of babies, two minutes at 4 feet, front and back, will be found sufficient, repeated every second or third day, the child being held on the mother's lap for the four minutes.

For older children, three minutes at 3 feet to chest and back alternately, twice or three times a week.

For adults, three minutes at 3 feet chest and back may safely be given as initial doses.

Doses may be increased by one minute per week up to five or ten minutes, or longer, according to the reaction of the patient.

The first sign of improvement is increase of appetite, increased cheerfulness, and evidence of more energy and vitality. If the patient feels brighter and better after his treatment, the dose is suitable, and may be gradually increased. If, on the other hand, he complains of lassitude, irritability, slight headache, or loss of appetite, the dose is too large, apart from any question of whether there was an erythema reaction or not. Such persons crop up every now and then. They almost always have a low blood pressure. The dose should be reduced, and small areas irradiated—say, the face and arms only, or the chest only—for half a minute at 4 feet, gradually increasing. The patient, as a rule, then does well, but be on the lookout for the " critical point " in these persons, and keep below it.

Quite a good plan is to give mild baths, as above, to the whole body, and once a week produce a second degree erythema over a circumscribed area about 9 inches square, choosing a different site for the erythema each week. This is a useful procedure where the patient has any septic focus.

The above remarks apply to general irradiation. In dealing with localised lesions, and the cure of such conditions

as lumbago, sciatica, and neuritis, where the production of a strong erythema is desired, the beginner should start off with a trial series of doses through small windows cut in paper or cardboard (see p. 24). Thus two minutes, four minutes, and eight minutes at 1 foot may be tried on the skin of the abdomen or forearm, and the results observed next day. It will then be an easy matter to calculate exactly what dose is required for the particular patient to obtain the degree of erythema desired. After a very short experience the practitioner will be able to dispense with the trial-window method.

In cases of lupus, telangiectasis, and keloid scars, etc., a fourth degree reaction, or what is misnamed a "blistering burn," should be produced on small areas about once a fortnight. Should by chance such a burn be accidentally produced at any time during treatment, the practitioner need not worry. Such reactions are not painful like real burns, and they always rapidly clear up.

A useful table of relative sensitiveness of various parts of the body to ultra-violet radiation is given by A. J. Pacini:

Order of Sensitiveness to Ultra-Violet Radiation (Pacini)

Chest	1	Posterior leg	$1\frac{3}{4}$
Abdomen	1	Anterior leg	2
Back	1	Dorsum of hands ..	5
Anterior arm	$1\frac{1}{2}$	Palms of hands ..	15
Posterior arm	$1\frac{3}{4}$	Sole of foot	25

The figures after each part denote the sensitiveness of that part as judged by time at same distance. For example, if one minute at 1 foot produces a first degree erythema on chest, to get the same effect on the sole of the foot would require an exposure of twenty-five minutes at 1 foot.

6. Dangers of Ultra-Violet Radiation

Individual Overdose of Ultra-Violet Radiation

In the hands of a careful physician it may be stated that there are practically no dangers. Nevertheless, there exist certain types of patient where the administration of ordinary doses of ultra-violet radiation results in certain untoward

symptoms, even in the absence of erythema. After general irradiation there is no feeling of well-being, but instead there is depression. After a period of from four to six hours, or even earlier, there is headache, loss of appetite, lassitude, depression, irritability, and sometimes nausea. There may be slight looseness of the bowels. The patient may be somewhat better next day, but still feels "out of sorts." Such untoward symptoms are most likely to be met with in dark people or in red-haired people, and women seem to be affected more often than men. By far the largest number of these cases occur where there is a markedly low blood pressure, but some glycosurias and some cases with pulmonary tubercle are thus affected.

When sensitiveness of this type is met with, reduce the dose and the number of applications—say to half a minute at 4 feet to the face and forearms only with several days' interval, and gradually increase the area exposed and then the time of exposure.

There is a very definite "critical point" in these cases, and this must not be passed.

By the use of these subminimal doses such patients will usually respond as the ordinary individual does, and experience increased energy, appetite, and a feeling of *bien-être*.

Lastly, if any patient is febrile, great care must be used in applying ultra-violet radiation. Further experience is required in the treatment of febrile cases before any law can be laid down. At present most writers regard fever as a contra-indication. In the writer's series, observations were made immediately before and after treatment, with the following results after exposure to the rays, in patients with normal temperatures:

Temperature was observed in 216 instances, and was found to be *raised* in 109 instances, *lowered* in 73 instances, and *unchanged* in 34 instances. The average rise in temperature was 0·45° F. The average fall was 0·45° F.

Pulse was observed in 187 instances. The pulse rate was increased in 64 cases, decreased in 100 cases, and remained

TABLE OF SUGGESTED INITIAL DOSES WITH QUARTZ MERCURY VAPOUR LAMP OF STANDARD PATTERN IN CERTAIN COMMON CONDITIONS.

The reader will understand that on the question of dosage it is quite impossible to lay down any hard-and-fast rule. Each patient must be treated individually, and questions of colouring, sensitiveness to summer sunlight, and blood pressure taken into account. The suggested times and distances given below are rough indications only, and must be accepted as such, being approximately safe, and at the same time useful initial doses for the average patient. The practitioner will modify these suggestions according to the output of ultra-violet rays from his own particular lamp. With a new lamp much valuable information can be obtained by the " trial-window " method on the doctor's own forearm or on his patient.

Disease.	*Time in Minutes.*	*Distance in Inches.*	*Erythema Reaction desired.*	*Intervals between Treatments.*	*Remarks.*
Skin Diseases :					
Dermatitis	4	12	2nd or 3rd degree	2 to 3 days	
Eczema	4	18	2nd ,,	2 ,, 3 ,,	
Lupus and scrofuloderma ..	5	6 locally	4th ,,	2 ,, 3 weeks	Also general irradiation of body 3 minutes at 36 inches bi-weekly. Produce 4th degree reaction every 14 days on lupus patch.
Xerodermia	5	30	2nd ,,	4 days	
Psoriasis	5	30	2nd ,,	5 ,,	
Chilblains (prevention of) ..	3	24	1st ,,	2 ,,	General irradiation.
Chilblains of hands ..	10–15	8	2nd ,,	Daily	Reduce dose as chilblains heal.
Burns	2	12	1st ,,	Daily	
Impetigo	5	12	3rd ,,	2 to 3 days	After removing crusts with starch poultice or normal saline.
Herpes	3-5	12	3rd ,,	2 days	
Erysipelas	2	18	2nd ,,	Daily	

Furunculosis	4	6	3rd degree	2 days	Through window in adhesive plaster or paper over boil. Also give general irradiation.
Acne vulgaris	4	20	2nd or 3rd degree	4 ,,	
Acne rosacea	5	12	3rd ,,	6 ,,	
Keloid scars	4	6	4th ,,	14 to 21 days	
Alopecia	8	8	3rd ,,	7 days	To scalp. In severe cases, continue weekly for 12 to 18 months.
" Rheumatic " Diseases :					
Neuritis	3	18	2nd or 3rd degree	5–6 days	
Sciatica	5	12	3rd ,,	6 days	Along course of nerve. Give general irradiation also.
Lumbago	5	12	3rd ,,	3 ,,	Over lumbar region.
Chorea	2–3	36	1st ,,	3 ,,	Increase dose slowly.
Respiratory Diseases :					
Pulmonary tubercle ..	2	40	0 ,,	1 day	To face, hands, and arms only at first. Gradually increase first the surfaces irradiated and then the time. Lastly, reduce distance.
Post-influenzal states ..	2	36	0 ,,	3 days	To chest and back. Increase dose cautiously. Observe blood pressure.
Coryza	3	36	1st ,,	3 ,,	To chest and back. Too large a dose will make coryza worse.
Bronchitis	3	30	1st ,,	2 ,,	General irradiation with weekly erythema of 1st degree to chest and back alternately.
Other Conditions :					
Rickets in babies	2	48	0 ,,	1 day	After a few doses reduce distance to 36 inches.
Debility	2	36	0 to 1st degree	2 days	Avoid erythema till one finds out response of patient to ultra-violet radiation.

the same in 23 cases. The average increase of frequency was five, and the average decrease was five beats per minute. The temperature of the treatment room was 65° to 68° F.

Blood Pressure.—The systolic readings showed an increase in 13·3 per cent. of the cases examined, a fall in 53·3 per cent., and remained unchanged in 33·3 per cent. The average fall was 6 to 8 mm. The diastolic readings showed an increase in 13·3 per cent., a fall in 46·6 per cent., and remained unchanged in 40 per cent. of the cases examined. The average fall was 3 to 4 mm.

If the practitioner will proceed on the guiding principles laid down in this little book and summarised in the last chapter, he will find himself becoming enthusiastic over this form of treatment; he will find that very soon a little "light clinic" will appear in his practice, and his interest and that of his patients will increase in all that pertains to ultra-violet radiation.

CHAPTER VIII

CONCLUSIONS

I. RESEARCH has demonstrated that exposure to ultra-violet radiation has a *direct* bactericidal effect on the surface of the skin.

In addition, certain definite *indirect* effects are produced:

(*a*) Increase in the bactericidal power of the blood.

(*b*) Increased retention of calcium and phosphorus and iron in the body.

(*c*) Stimulation of cell metabolism.

(*d*) Analgesic effect on the skin.

(*e*) A general "tonic" effect.

II. Despite much valuable research on ultra-violet rays, the exact method by which these invisible rays act on tissue and tissue fluids is not yet known. The well-defined latent period between exposure and the response of the skin by the production of an erythema is still unexplained.

III. While many observers lay great stress on the production of erythema in the treatment, both local and general, of disease, the writer has demonstrated that quite definite and satisfactory results may be secured without the production of erythema. In many local conditions he agrees that the duration of treatment may be curtailed by the production of a sharp erythema, especially in diseases where a rubefacient effect is desirable.

IV. Ultra-violet radiation seems to bring metabolic processes to a normal level, paradoxical as it may at first sight appear, whether these processes are above or below normal.

V. Ultra-violet radiation, used with patience and care, is capable of:

(*a*) A direct bactericidal effect on surfaces and fluids.

(*b*) A detoxicating effect on certain toxins.

(*c*) Increasing indirectly the resistance of the body to infection by raising the bactericidal powers of the blood.

(*d*) Acting as a remarkably effective rubefacient and counter-irritant.

(*e*) Acting as a powerful analgesic on skin surfaces.

(*f*) Stimulating metabolism of the body, particularly the mechanism associated with growth in young children.

(*g*) Depressing the body metabolism if large or unsuitable doses are given, particularly in febrile cases, or in asthenic persons. In these cases the estimation of the blood pressure gives useful information as to dosage and progress, a practical point not brought out in the literature.

(*h*) Aiding mineral metabolism of the body, especially in young children, and especially in relation to calcium, phosphorus, and iron.

VI. An agent which will secure such beneficial reactions as those outlined above is particularly adapted for use in every modern public health department, and in the surgery of every practitioner. From infancy onwards our children are starved of light in our smoke-enshrouded towns. Light is intimately associated with growth processes, and yet at the age of five years, or even earlier, just when growth is most active and light most needed, we shut up our children in unhygienic schools during hours when sunshine is available. Comment is hardly needed when one states that the greatest incidence of disease in children coincides with the time when they enter upon school life.

VII. A very wide field of application awaits the use of ultra-violet radiation in the maternity and child welfare branch of public health activity. Ultra-violet radiation cures rickets consistently and rapidly.

Ultra-violet radiation should be available in every infant welfare scheme in every town. Prophylactic use of ultra-violet radiation in the first year of life would banish rickets, tetany, and spasmophilia from our infant population.

VIII. In the treatment of tuberculous disease, ultra-violet radiation exerts a marked curative effect in skin tuberculosis, bone and joint tuberculosis, mesenteric tuberculosis, and gland tuberculosis, and in the order given. In lung

tuberculosis further experience is required. In the meantime, cases of pulmonary tuberculosis should be watched with particular care, and minimal and very gradually increasing doses of ultra-violet radiation given.

IX. A field opening up many possibilities remains to be explored in the action of ultra-violet radiation in rendering inert substances therapeutically and otherwise active.

X. While ultra-violet light has been known for more than a century, it is only comparatively recently that its wide application and therapeutic possibilities have begun to be explored. As in the case of the X rays, time and patient enquiry are required before its exact scope in therapeutics can be defined, but sufficient solid evidence of its utility in many fields of medicine is available to indicate its use in the practice of every modern physician.

CHAPTER IX

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